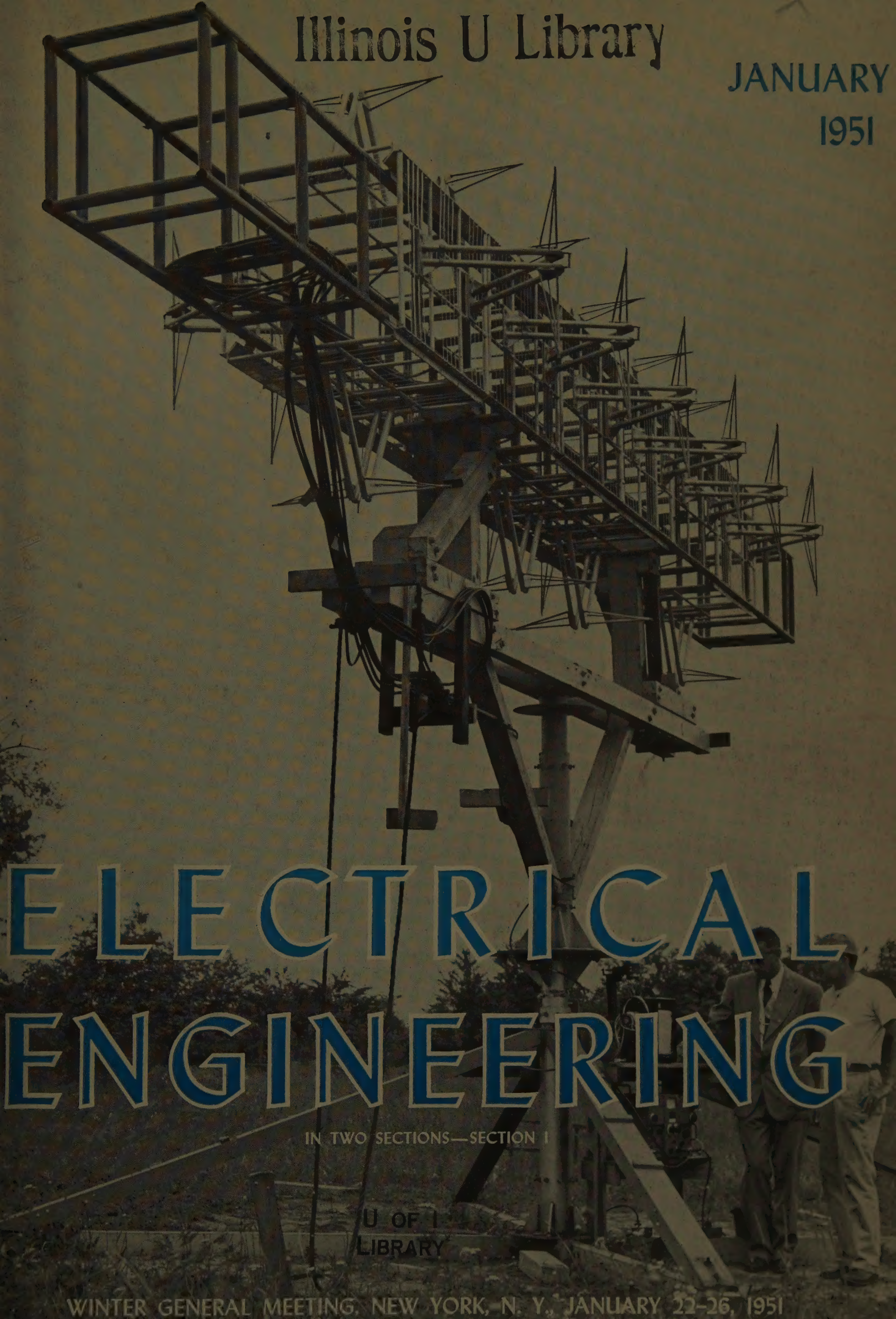
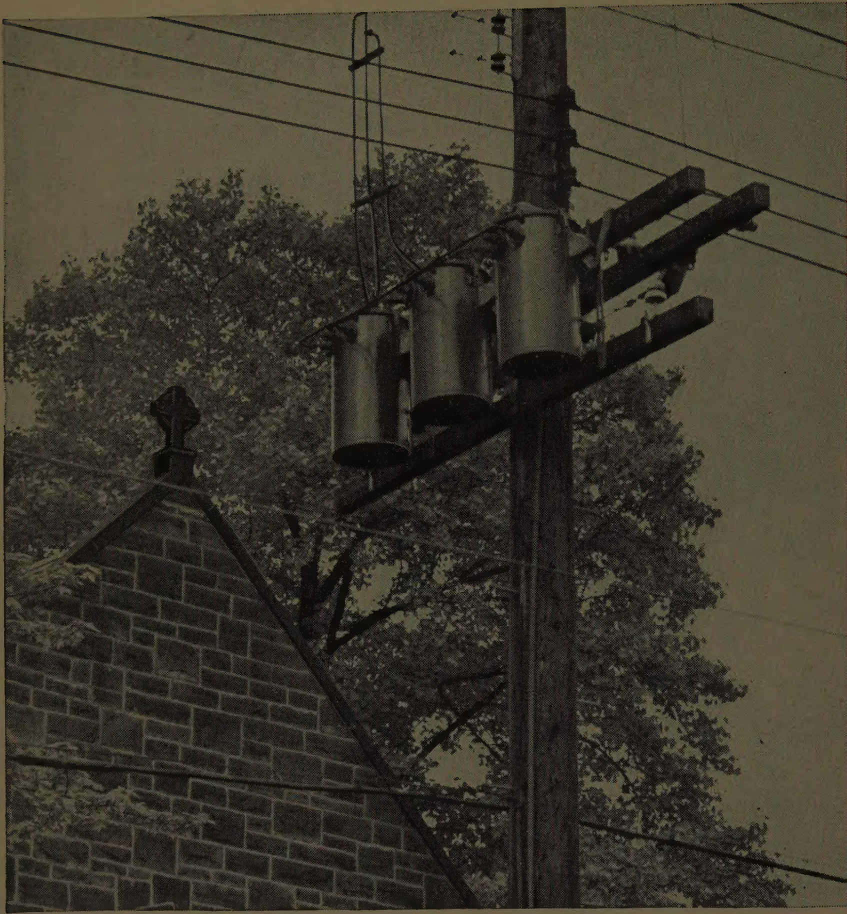
JANUARY
1951

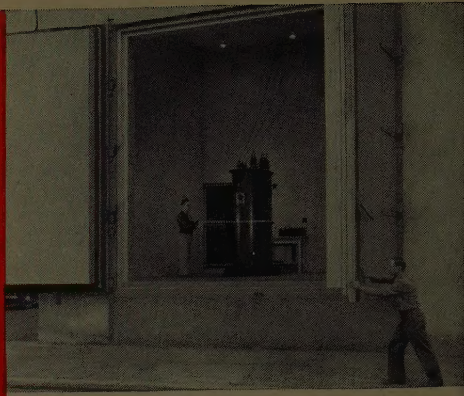


ELECTRICAL ENGINEERING

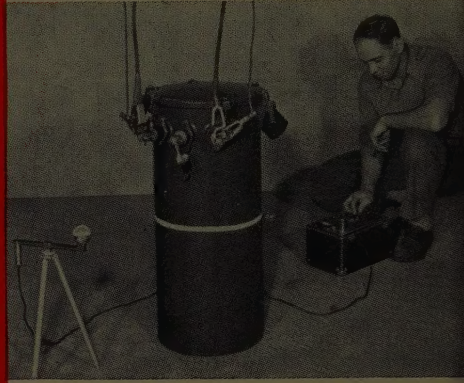
IN TWO SECTIONS—SECTION I

WINTER GENERAL MEETING, NEW YORK, N. Y., JANUARY 22-26, 1951





A 1000 kva power transformer ready to receive sound level tests in Allis-Chalmers Pittsburgh Works sound laboratory. Laboratory walls of concrete, glass wool and acoustical tile exclude 99.98% of exterior noise power.



Here a distribution transformer is getting sound and harmonic analysis. Physical noise level and harmonic index are new tools to measure sound energy. Transformer designs, in addition, are tested in accordance with ASA and NEMA standards.

Quiet Neighborhoods NEED QUIET TRANSFORMERS

How to Beat Transformer Noise—That's The Problem Allis-Chalmers Engineers Are Tackling In Their Pittsburgh Sound Laboratory

TODAY'S DEMAND FOR quieter transformers is stronger than ever before. Larger rated transformers are moving into residential areas as distribution systems grow up. That's why holding customer good will depends more and more on keeping transformer sound level low.

What is Allis-Chalmers doing about sound level? In cooperation with sound experts, Allis-Chalmers engineers are conducting research on new electrical core steels in an effort to reduce magneto-striction and resonance. They're testing effects of clamping pressures, core impregnation and anchoring of core and coil assembly. Their laboratory is specially equipped for sound level experiments.

What will be the result? Transformers that create good will. Research, engineering and production are teaming up at Allis-Chalmers to give you a transformer that is truly a good neighbor.

For details on Allis-Chalmers transformers contact your nearby A-C sales office or write for bulletins:

Bulletin 61B7309A — *ACP* (Allis-Chalmers self-protected) distribution transformers.

Bulletin 01B6168B — Complete A-C power and distribution line.

Bulletin 61B6014A — Substation transformers, 50 to 500 kva.

A-3170

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MILWAUKEE, WIS.

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ELECTRICAL ENGINEERING

Registered United States Patent Office

JANUARY

1951

The Cover: The antennas and reflectors of one of the five new television antenna arrays designed for the multiple antenna system to be used on the Empire State Building are shown. In making tests the antenna is used as a receiving antenna to pick up a signal from a fixed transmitter located a short distance away. Received signal is measured by field intensity meter at lower right and recorded on the Esterline-Angus Recorder as the antenna is rotated. Vertical radiation pattern is determined by this method. To determine horizontal pattern the antenna structure is mounted vertically and rotated about the vertical axis (see page 2).
RCA photo

VOL. 70 NO. 1

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HIGHLIGHTS........

1950 Index. The 1950 Index to *Electrical Engineering* is being distributed with this issue as Section 2. It is subdivided into subject, author, AIEE and non-AIEE news, and biographical indexes.

1950 Engineering Developments. At the close of each year, the many achievements and developments in the field of electrical engineering of the past 12 months are considered and evaluated. In this issue a picture survey reflecting some of the year's significant engineering developments is presented. In addition, this year a number of the AIEE technical committees review various outstanding engineering developments of 1950 that fall within their particular scopes (*pages 2–26*).

Winter General Meeting. The 1951 Winter General Meeting will be held January 22–26 at the Hotel Statler, New York, N. Y. The schedule of inspection trips for the meeting is a most interesting one, including a tour of the Hastings, N. Y., plant of Anaconda Wire and Cable Company, United States Signal Corps Engineering Laboratories at Fort Monmouth, N. J., and a visit to the North Queens Substation and Astoria Repair Shop. Presentation of medals and prizes will be given at three General Sessions. The tentative technical program for the meeting is included (*pages 71–78*).

Board of Directors Meets. A regular meeting of the AIEE Board of Directors was held in conjunction with the Fall General Meeting. Among other actions taken at the meeting, the Board approved the establishment by the Engineers Joint Council of an Engineering Manpower Commission and appointed representatives to it (*pages 80–82*).

Electrical Essays. The third in a series on Motionally Induced Electromotive Force by J. Slepian, as well as two short articles by A. A. Kroneberg, make the electrical essays this month very interesting (*pages 67–70*).

Industry Appraises and Develops the Engineer. The interdependence of industry and the engineer is discussed by Past President Lee. The contributions of one to the other are most interestingly detailed (*pages 27–28*).

Microwave Applications. Studies of many types of channels for communications for use on the Bonneville Power Administration included the following types: toll and exchange service, leased circuits, government-owned wire lines, medium-frequency radio, very-high-frequency radio, power line carrier, and microwave radio. A discussion of these studies presented this month shows why it was decided to use microwave radio over the backbone routes and carrier over the branches (*pages 29–33*).

Thickness Measurement by Radiation Backscattering. Measurement and control of the thickness of thin coatings on materials is now possible in production by the use of backscattered radiation. The radioactive substance and an isolated detector are placed on the same side of the substance to be measured, and the response of the detector indicates the thickness of the coating (*pages 35–37*).

Testing Aircraft Electric Motors. The problem of designing testing machinery for aircraft equipment which will not be obsolete before it is built is discussed by I. E. Ross of the General Electric Company. Mr. Ross describes the testing program designed by one manufacturer to evaluate the performance of aircraft rotating electric equipment weighing less than 100 pounds (*pages 41–46*).

A Negative-Impedance Network. Designed for use in exchange area circuits, the newly developed *E*1 telephone repeater will improve transmission on these lines by lowering transmission losses. They reduce losses on trunks from a distant office to tandem, on trunks connecting a local central office to a toll switching point, and on special service lines where existing line facilities would result in poor transmission (*pages 49–54*).

The Magnetic-Particle Power Clutch. Since the introduction of the magnetic clutch in 1948, it has been accepted in many fields. It has been applied to a motor-generator set with a 3,428 rpm generator speed, and the Navy is using it to control the speed of a 400-cycle alternator driven by a 60-cycle motor (*pages 57–59*).

Basic Impulse Insulation Levels. An analysis of present-day conditions on systems op rating at nominal voltages of 115 kv and higher lead to recommendations for changes in Basic Impulse Insulation Levels. A discussion of the proposed changes is presented this month (*pages 61–66*).

News Index

AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions.*

AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jan '47, pp 82–3*). They are available to AIEE Student members, Associates, Members, and Fellows only.

All technical papers issued as AIEE *Proceedings* will appear in *Electrical Engineering* in abbreviated form.

Location of Order Forms	Meetings Covered
Feb '50, p 46A	Winter General
Jul '50, p 30A	Winter General North Eastern District Great Lakes District Summer and Pacific General
Nov '50, p 43A	Middle Eastern District Fall General

ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office 20th & Northampton Streets, Easton, Pa. Editorial and advertising offices 500 Fifth Avenue, New York 18, N. Y. Subscription $12 per year plus extra postage charge to all countries to which the second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Easton, Pa., under the Act of Congress of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P. L. & R. Act of February 28, 1925. January 1951, Vol. 70, No. 1. Number of copies of this issue 56,000

Happy New Year

How nice 'twould be if we could send
To every engineering friend
A special verse or New Year's card,
But you're so many it's too hard.

Instead we'll take this page again
To greet you 50,000 men
And share this brief philosophy:
A New Year's thought for you and me.

Just looking back at this past year
Was I a useful engineer?
What did I do in twelve months' past
To build a mansion that will last?

There are so many things so new
That we as engineers can do.
If in '50 they were not done
We must do better in '51.

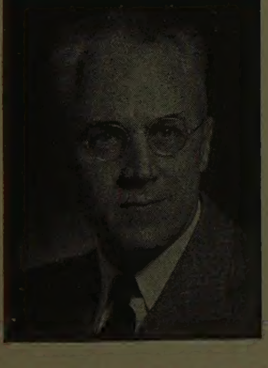
A minister may save the soul;
A doctor keeps the body whole.
Ours seems to be a broader field:
The force of nature we must wield.

No matter what there is to solve
Let's each this New Year's Day resolve:
"Whatever I plan, design, control,
I'll do my part to reach this goal:

"More comfort, food, and cleanliness;
More time for leisure and for rest;
Achieved in some new simpler way
At price men can afford to pay."

Titus G. LeClair

PRESIDENT AIEE

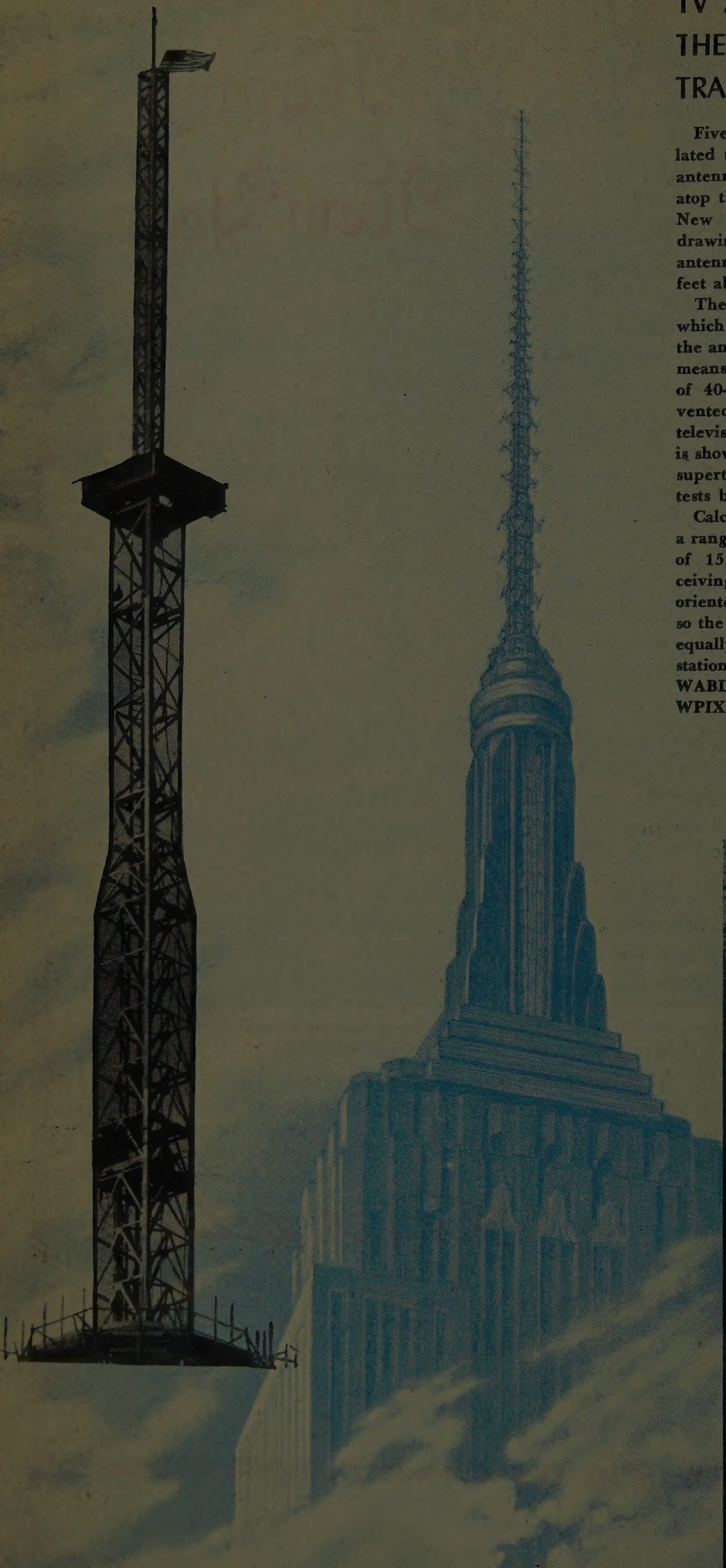


TV AND FM ANTENNAS ON THE EMPIRE STATE BUILDING TRANSMIT SIMULTANEOUSLY

Five television and three frequency-modulated transmitters will employ simultaneously antennas on the new 222-foot mast erected atop the tower of the Empire State Building, New York City (shown in the architects' drawing) giving these stations the highest antenna facilities on the Atlantic coast, 1,522 feet above sea level.

The composite telephotograph at the left, which shows the mast before the installation of the antenna arrays, was taken a mile away by means of a Contax camera with a Reflectar lens of 40-inch focal length. This lens was invented by Dr. Frank G. Back especially for television close-ups. In the illustration below is shown the assembling of the WNBT 4-layer superturnstile antenna prior to its preliminary tests by RCA engineers.

Calculations show that the stations will have a range of 52 miles and an estimated audience of 15,000,000. One advantage to the receiving-set owner is that his antenna can be oriented directly on the Empire State mast and so the five stations' signals should be received equally well. It is expected that the following stations will broadcast from here early in 1951: WABD, WCBS-TV and FM, WJZ-TV and FM, WPIX, and WNBT and WNBC-FM.



1950 ENGINEERING DEVELOPMENTS

Reviewed by AIEE Technical Committees

NOTEWORTHY ADVANCES were made in the electrical engineering field during 1950; they may be divided into five broad categories: communications, power, science and electronics, industry, and general applications. The highlights in communications were the Federal Communications Commission's decision to authorize the field sequential color television system as standard, extension of television broadcasting, and further growth of microwave networks. The power field saw plans made for the construction of a 300/315-kv line which will be the highest voltage line in the United States. More and more centralized control rooms are being used, and this year saw the installation of the first completely centralized control board for a large steam-generating station. The continued improvement and reliability of electronic components has helped to increase the use of electronic computers in business, research, design, statistics, and military fields. Several new types of radiation detectors, some quite inexpensive, have been put on the market. In industry, electric welding has shown many gains; automatic equipment is being used, and speed and flexibility have been attained. Electrical controllers for many industries have been developed. General applications of electrical engineering have been many. In land transportation the trend from steam to Diesel locomotives has continued unabated, and lightweight traction motors and associated equipment have been put into use. The number of heat pumps in operation has increased to about 750. Some of the 1950 engineering developments are reviewed here by the AIEE technical committees.

Communications

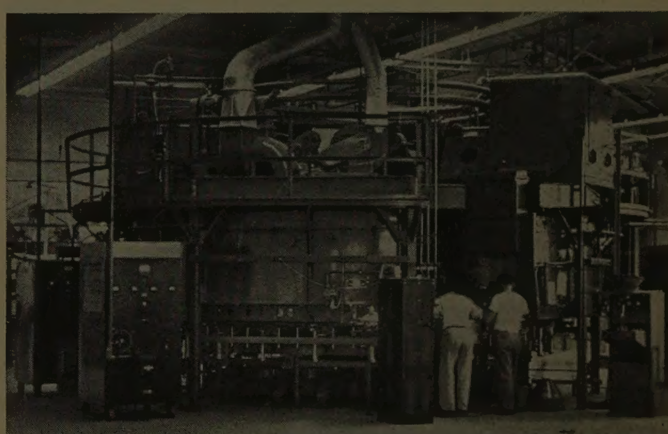
TELEVISION AND AURAL BROADCASTING SYSTEMS

THE GREATEST ACTIVITY in the field of broadcasting was in television, and the unprecedented expansion of television broadcasting continued throughout 1950, although construction of new television stations has been frozen by the Federal Communications Commission (FCC) since September 1948. Extension of the Bell Telephone system's video cable and microwave television circuits, particularly to the south and west, permitted wider distribution of programs which continued to expand both in quantity and quality. Important developments occurred in the field of color television during 1950. The FCC hearing on this subject, which started in September 1949, continued through the first half of 1950 and resulted in the FCC issuing standards based on the field sequential color system, with different scanning standards for monochrome and color television.

New developments in aural and visual broadcasting studio equipment included improved magnetic-tape editing facilities and unobtrusive television program microphones. New television cameras featured smaller pickup tubes, locking circuits to facilitate picture lapping, and magnetic sound tracks for film programs. Several proposed 6-megacycle-channel visual color systems were demonstrated.

Aural broadcast transmitters featured size reduction, circuit simplification, and latest power tube developments. Ultrahigh-frequency visual transmitters were placed in operation experimentally. New very-high-frequency transmitters utilized latest very-high-frequency tube types.

Radiating systems for visual broadcasting featured higher gain, simplified feeder lines, and multichannel



This new automatic rotary baking and exhausting machine for television picture tubes is located in the Sylvania Electric Products, Inc., plant at Seneca Falls, N. Y. The machine, believed largest of its type, is 30 feet in diameter

transmission from single structures, notably, the 5-channel Empire State Building installation in New York, N. Y.

Aural broadcast receiver production during the year was at a high level with many new models being introduced. Increased emphasis has been placed on design of both frequency-modulated and television receivers to reduce radiation so that this will not be a source of interference. For television receivers, the year 1950 has seen universal adoption of filter-face picture tubes in both glass and glass-metal, and a strong trend toward rectangular tubes. Round and rectangular 16-inch tubes are the most popular, with an increasing number of 19- and 20-inch sizes being manufactured. Uniformity of focus has been improved by corrective yoke design. Hold and brightness controls are being concealed or placed on the rear of the sets resulting in simplified customer operation. The intercarrier sound system is in general use and more efficient uniformity deflection circuits have reduced power supply requirements. A 41-megacycle intermediate frequency is in limited use. All manufacturers are faced with the problem of operation on Columbia Broadcasting System color standards, and some are beginning to provide sockets for connection of adapters or converters.

TELEGRAPH SYSTEMS

PROBABLY the most important technical development in telegraph message handling during the past year was the cutover of the Portland, Oreg., office to reperforator switching operation, marking the completion of the initial phase of a nationwide telegraph network which largely eliminates the need for manual handling of messages.

Clerks at push buttons switch telegrams into the Western Union local distribution network at Portland, Oreg. This installation completed a nationwide telegraph network which reduced manual handling of messages to a minimum

A significant development in submarine cable telegraphy was the successful installation of the first submerged cable repeaters. Installation on an existing North Atlantic cable between Bay Roberts, Newfoundland, Canada, and Penzance, England, increased the allowable speed of the cable by 100 per cent, and installation on the new Havana-Key West cable made possible a 12-channel carrier telegraph system between these points.

In the field of international telegraphy, a new system of direct interconnection of printers on a subscriber-to-subscriber basis was introduced, operating initially between New York, N. Y., and The Netherlands, with plans for expansion to other countries.

The growth of facsimile operation was marked by several significant items: the large-scale use of a miniature facsimile machine only 10 by 11 by 7 inches for use in customers' offices to provide rapid and convenient connection to the modernized telegraph network; the successful use of a telephotograph level compensator, thus far used only in critical cases but now being standardized, which minimizes amplitude fluctuations on broad-band telephone systems and stabilizes picture transmission; and the use of radio-equipped automobiles with facsimile recording apparatus to provide a front-door telegraph service to residential users in Baltimore, Md.

Other important items include a successful electronic time division multiplex set already in extensive use on government radio circuits; increased use of short-haul carrier telegraph systems to alleviate the shortage of d-c wire facilities; development and use of electronic means for interconnecting intercity lines and subscribers' loops; and the extensive application of carrier systems for the derivation of telegraph channels from broad-band wire systems, including coaxial cables.

COMMUNICATION SWITCHING SYSTEMS

THE FOLLOWING examples are typical of the significant developments completed in the communication switching field.

A new machine switching toll system, called the *A4A*, has been put into service in the Bell Telephone system. The *A4A* is an advanced version of the *4*-type toll switching system,[1] and represents the intermediate step between this earlier and the ultimate *4A* system now under development for nationwide dialing. The chief advantage of the *A4A* over the earlier *4*-type system is that it can use part of the dialed information to establish a connection, and pass along the same information—together with the rest of the dialed information—to the next switching point, thus economizing on the amount of required dialed information. The *A4A* system also has some automatic alternate routing and code conversion features and is readily convertible into the future *4A*-type system. The first *A4A* system was installed in Albany, N. Y. Succeeding installations were made in Indianapolis, Ind., Baltimore, Md., Washington, D. C., and Kansas City, Mo.

In the Los Angeles area a new Universal Director[2] for use in local step-by-step exchanges was put into service by the Automatic Electric Company. This new director has a call-translating arrangement common to all directors of the office, which translates the called office code to regular dial-type routing impulses if the normal path for the call is available, or to alternate-routing dial-type impulses if the normal path is busy, or to revertive type of impulsing

f the call has to be established via a connecting panel-ype local office. The director also can be associated with he automatic short-haul toll ticketing (*SATT*) system.

References

. Crossbar Toll Switching System, L. G. Abraham, A. J. Busch, F. F. Shipley. AIEE *Transactions*, volume 63, 1944, pages 302–9.

. The Universal Director in Strowger Automatic Telephone Systems, J. E. Ostline. AIEE *Transactions*, volume 69, part II, 1950, pages 1080–7.

WIRE COMMUNICATIONS SYSTEMS

NEW MEDIUM-LENGTH carrier telephone systems of various kinds were developed for use on open-wire and cable facilities. This should reduce the demand for scarce materials and keep telephone circuit costs down.

The television network was extended to 14 new cities in the southeast and middle west, mainly by coaxial cable but partly by radio relay. The main network now extends from Boston, Mass., to Jacksonville, Fla., Kansas City, Mo., and Minneapolis, Minn., and connects about 50 television cities in this area.

A carrier telephone cable was laid from Key West, Fla., to Havana, Cuba, with repeaters sealed in the cable and buried under the water.

A negative-resistance repeater was developed for use on short circuits to give small or moderate gains.

RADIO COMMUNICATIONS

A CHAIN of microwave radio relay stations has been extended by the American Telephone and Telegraph Company to Omaha, Neb., linking Chicago, Ill., Toledo, Ohio, Pittsburgh, Pa., and other intermediate cities with the network centered at New York, N. Y. The new stations are designed to carry hundreds of telephone conversations as well as several television programs.

Several pipelines, railroads, and power companies have announced plans for constructing microwave radio-relay chains totalling several thousand miles to provide multiplex communication channels for their systems.

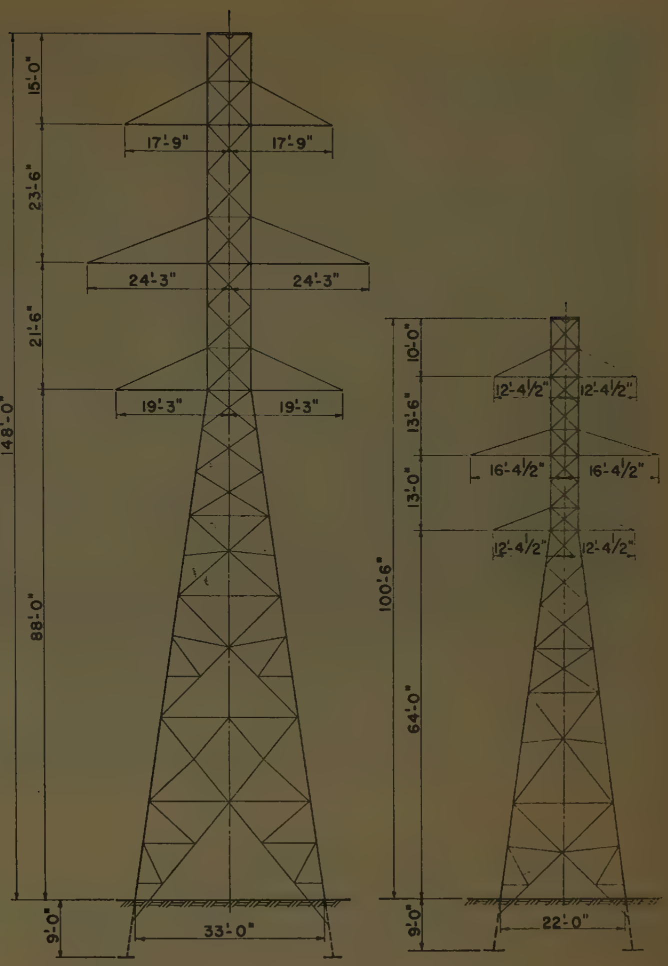
Mobile radio telephones continued to increase in number, serving small boats as well as trucks, busses, taxicabs, and private motor cars.

Terminal equipment capable of detecting an unbalance of the normal ratio of three mark and four space elements of the 7-unit code, and automatically interrupting transmission while the signal is repeated until correctly received, has been placed in service at The Hague by the Netherlands Postal and Telecommunications Service on several radio telegraph circuits, including that with Radio Corporation of America Communications at New York, N. Y.

Power

TRANSMISSION AND DISTRIBUTION

BRINGING TO FRUITION the results of field research of corona and radio influence on extra-high-voltage lines, construction has started on the highest voltage line in this country which will be a part of the American Gas and Electric Company system. The line, which in effect will be one section of a superimposed high-voltage "backbone" of the company's present 138-kv system in Ohio and Virginia, will be rated 300/315 kv and is designed for a maximum operating voltage of 330 kv. This first section will be of 2-circuit design.



Comparison of a typical tower of the planned 300/315-kv line to be added to the American Gas and Electric Company system with a tower of the 138-kv line now in operation

This higher transmission voltage has required a new basic impulse insulation level for the equipment to obtain maximum economy in first cost, while at the same time aiming to provide high-grade service reliability.

In England a 275-kv line is being constructed, and in Sweden a 380-kv line is being erected. In both cases, it is reported, these lines will be operated initially at reduced voltages of 132 kv on the 275-kv system, and of 220 kv on the 380-kv system.

In the distribution field it is reported a higher voltage is being used on some rural distribution lines, namely, the Y voltage of 14.4 kv, or approximately 25 kv. Here again a new basic impulse insulation level is being proposed. Lightning protection and performance of transmission lines has received continued attention and study. The specialists in this field have agreed upon and published methods of predetermining the lightning performance of lines of different insulation, designs, and geographical locations, using both wood-pole and steel-tower construction, and taking into account the effect of ground, or tower footing, resistance.

Courtesy General Electric Company

The Schiller Station of the Public Service Company of New Hampshire, which was opened January 19, 1950, is equipped with generating apparatus which makes combined use of mercury vapor and steam turbine units

POWER GENERATION

Central station capacity in the United States continues its record-breaking trend with a total of more than 68,000,000 kw installed by the year's end. About 6,500,000 kw were installed during 1950. The new capacity scheduled for following years is: over 6,000,000 kw in 1951, about 8,000,000 kw in 1952, about 2,600,000 kw is planned for 1953 at present.

Only a few plants will be completely outdoors, many will be semi-outdoor, and others will follow the conservative practice of complete housing. Electrically driven auxiliaries continue to dominate present-day design. Increasing use of high-pressure high-temperature steam mitigates any advantages of steam drives. Over 80 per cent of the new units have only one boiler per turbine showing increasing reliance on higher availability of main equipment.

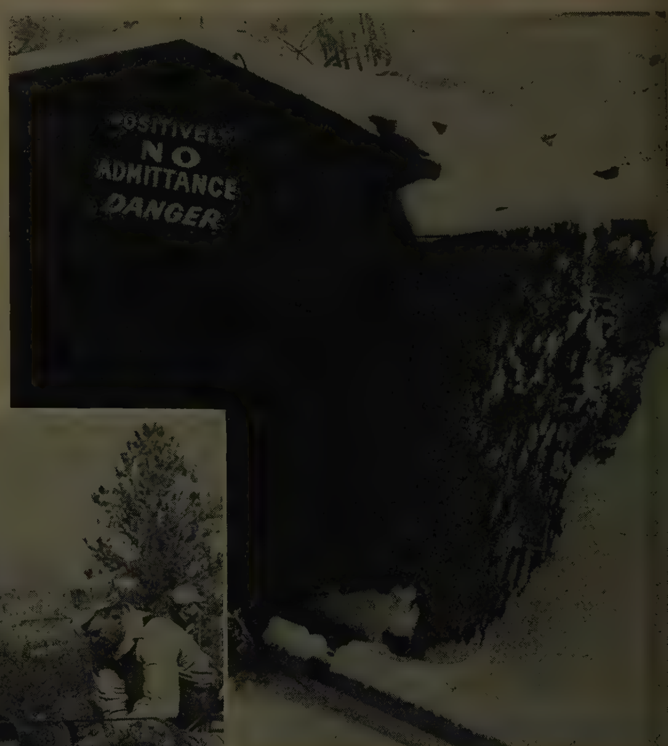
Centralized control rooms are finding increasing acceptance. Improvements in design include relaying arrangements to avoid bringing high-tension circuits and high-pressure high-temperature lines into the room; development of compact instruments to reduce size of panels; arrangement of instruments into logical and convenient order. All new stations reflect studied efforts to reduce station labor. Large-sized splash- and drip-proof motors are now being made available with accessible cleanout openings to reduce maintenance time and costs. Many plants have only two operating levels to minimize the number of operating attendants needed.

Welded construction of spiral casings and other components of reaction-type water wheels is finding increasing use with favorable results. Francis turbines are successfully operating with a 1,310-foot head in Norway. Waterwheels are under construction for a head of 1,440 feet.

INSULATED CONDUCTORS

The rapid increase in central station capacity in recent years has necessarily been accompanied

(Below) Three 69-kv ungrounded neutral cables being pulled into the pipe at the bell-mouthed feed-in tube on the end of a half-mile section of pipe



Photos courtesy Electrical Contractors, Inc., and C. M. Elliott

(Above) East portal of the Alva B. Adams Tunnel showing a half-mile section of the pipe which houses the cable being pulled into the tunnel on 2-wheeled dollies

A power transmission line was carried through the Continental Divide through the 13 1/2 mile Alva B. Adams Irrigation Tunnel. The cable, utilizing a 5 9/16-inch-diameter steel pipe as a container, was welded into 1/2-mile sections outside of the tunnel and three cables pulled upon a wooden track into the tunnel, raised to the ceiling of the tunnel above the water level, and joined to the preceding lengths

y corresponding increases in transmission and distribution nes. Many large capacity lines have been placed in service ecently at voltages ranging from 69 to 138 kv. Many f these lines consist of paper-insulated cables in steel ipes under about 200-pounds-per-square-inch pressure vith either oil or nitrogen gas as the pressure medium. Jsually these are buried in the earth, but in one case the ipe was installed in an existing irrigation tunnel 13 miles ong through the Rocky Mountains.

Through research work, the nature and extent of the losses n cables in steel pipes have been established. It has ecome possible to minimize such losses by proper conruction of the metallic insulation shielding tapes and of he skid wires on the outside of the cable.

Installations of large low-pressure oil-filled single-

he 1,750,000-circur-mil copper conuctor in this 69-kv il-filled cable has een made in four egments. If made onventionally, 35 per ent more copper vould have been needed

onductor and 3-conductor cables in conduits are being nade. In one case, the summer normal rating of a singleonductor 69-kv line is 140,000 kva with almost 100-per ent load factor, whereas the losses due to induced currents n pipe-type construction make its practical limit in carryng capacity about 100,000 kva in such a case. One reason or this is that for carrying capacities above about 100,000 va at 69 kv, the losses due to induced currents make the ipe-type impractical. The segmental type of conductor as been used for the first time in oil-filled cable with ollow-core for oil channel through the center in 2,750,000-ircular-mil cable. If the pipe type of construction had een used, about 35 per cent more copper would have een required.

A major limitation on cable loads has been the cracking f the lead sheaths in manholes due to thermal expansion nd contraction of the cable. Arsenical lead alloys have een developed that will stand the daily bending about hree times as long as lead sheaths will.

For synthetic rubber insulation for wire and cable, butyl

Application of the biased core principles and best Hipersil steel has allowed the reduction in size of current transformers from that of the two in the background to the one in the foreground

compounds have come into use. Their superior ability to withstand high temperature makes them attractive for some applications of high-voltage cables and of station cables. Some developments have been made in application techniques for synthetics which are used at high temperatures, such as the teflon- and silicone-type insulations.

For low-voltage use at very high temperatures, a cable with mineral insulation and seamless copper tube sheath has been developed. The insulation consists of compressed magnesium oxide.

Test methods have been developed for evaluating the resistance of various rubber and synthetic insulations to the effects of soil microorganisms.

SWITCHGEAR

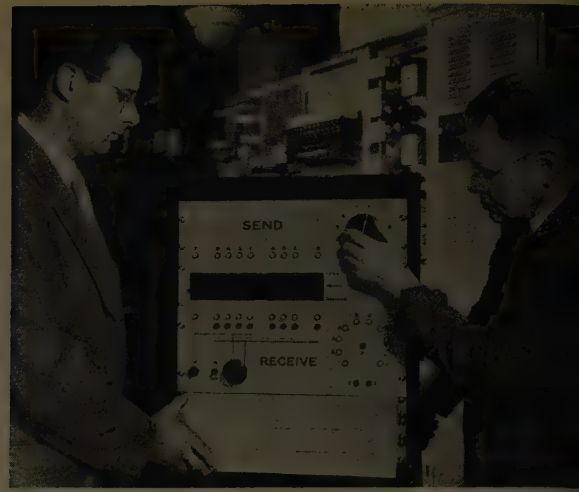
THE MOST outstanding development in the switchgear field was probably the installation and field testing of the largest outdoor oil circuit breakers so far built. These circuit breakers were rated 10,000,000 kva 230-kv and installed at Grand Coulee Dam. In proving the rating of these circuit breakers, record-breaking interrupting tests of 12,000,000 kva, 3-phase, were made. Both impulse-type and tank-type circuit breakers were used.

Also notable was the design and installation of a number of 69-kv 3,500,000-kva metal-enclosed compressed-air circuit breakers for outdoor service on the Consolidated Edison system. An installation of indoor station-type 14,400-volt isolated-phase air-blast circuit breakers also was made on the same system.

What is said to be the first completely centralized control board for a large steam-generating station was installed in the Morgan Creek Station of the Texas Electric Service Company. This board embodies all controls and complete

(*continued on page 18*)

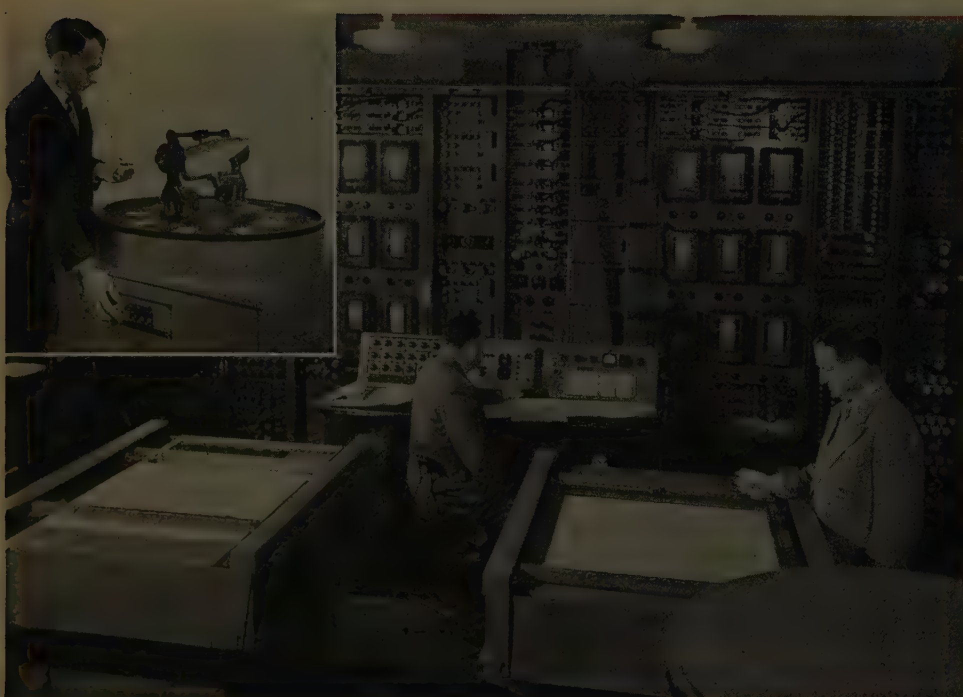
The Reeves Electronic Analogue Computer (REAC) can solve seventh order differential equations and may be used as a simulator or a tester of operating systems



A means for endowing computers with the faculty of correcting as well as detecting their mistakes has been developed at the Bell Telephone Laboratories. Mathematical research for the project was carried out by Dr. R. W. Hamming (left), and apparatus incorporating the discovery was constructed under the direction of B. D. Holbrook (right)

1950 ENGINEERING

A photographic record of some of the important

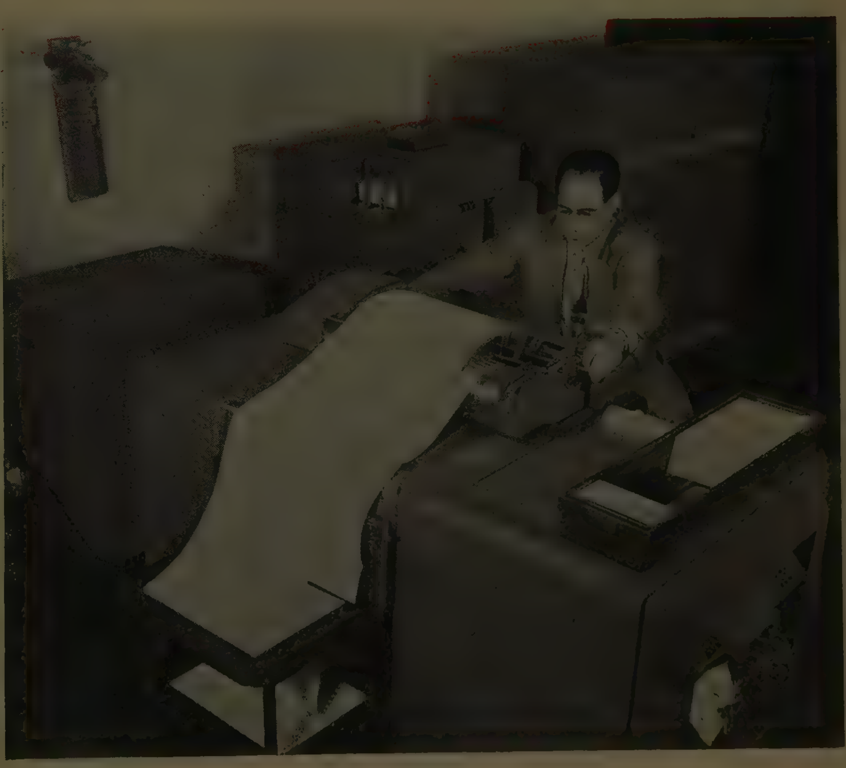


"Project Typhoon" is a new electronic computer designed to evaluate the performance of guided missiles, ships, airplanes, and submarines. The computer presents information traced in ink on a plotting board; 3-dimensional representations of the flights of missile and target are given by two suspended fluorescent balls, and a small-scale missile model simulates the performance of the antiaircraft missile under test (see inset). The heart of the computer is a new type of electronic multiplier which consists of a hybrid between analogue and digital apparatus. A staff of nine engineers and mathematicians as well as six technical assistants is required to operate this RCA Laboratories computer when it is solving complex guided missile problems

ions of the National Bureau ndards Computation Labora- are quite broad. In addi- to performing computations sted by Federal agencies, rsities, and private indus- the Laboratory works con- usly to create a stock pile of ematical tables. The effort is made to develop techniques numerical computation, par- rly those adaptable to auto- computing machines, and ain mathematicians in the cation of numerical methods. ng the facilities available in laboratory are a card pro- med calculator (right), SEAC er left), the Bureau's new -speed automatically se- ced electronic computer, and lectronic sorter (lower right)

DEVELOPMENTS

electrical engineering achievements of the year



TELEVISION

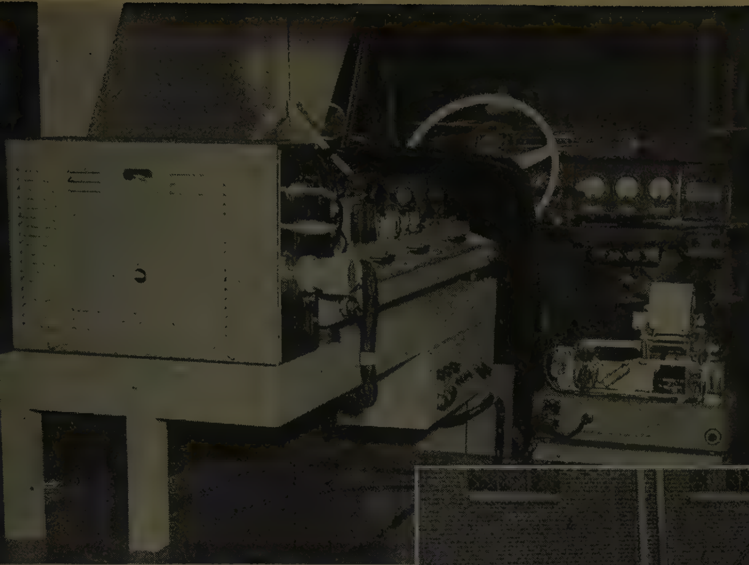
◀ A narrator can [illegible] indicate any point [illegible] a television screen [illegible] means of the [illegible] Electronic Poin[illegible] which appears [illegible] either a black or wh[illegible] rectangle. The p[illegible]tion of this poin[illegible] is controlled by [illegible] device similar to [illegible] control stick of [illegible] airplane, which [illegible] shift the light mar[illegible] quickly to follow [illegible] action. This is a [illegible]velopment of the G[illegible]eral Electric Compa[illegible]

▲ A new industrial television system comprises but two units: the camera is about as large as a home movie camera and the master control unit is no larger than a suitcase. This Radio Corporation of America equipment is readily portable and versatile in application

▲ A 200-watt ultrahigh-frequency television transmi[illegible] utilizing phase-to-amplitude modulation is being te[illegible] at the Stanford Research Institute, Stanford, Ca[illegible] where it was developed prior to its being put on the [illegible] as experimental station KM2XAZ at Long Beach., C[illegible]

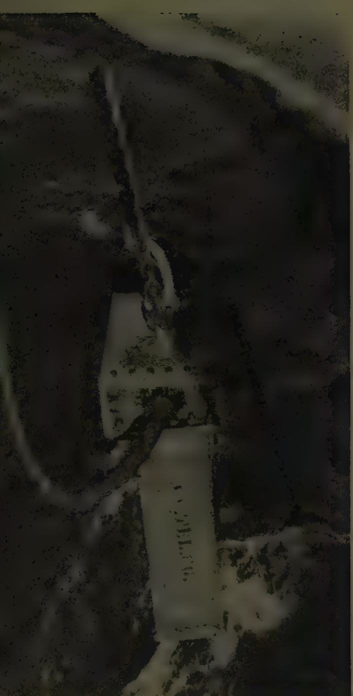
◀ Dr. Harvard L. Hull is seated before the screen of the 3-dimensional television receiver screen developed under his direction at the Argonne National Laboratory in co-operation with the laboratory of Dr. Allen B. DuMont, who is standing at the left. Dr. Hull is operating the master controls of the remote handling unit, the "slaves" of which can be seen at the right. This apparatus was developed so that radioactive materials can be handled in safety without exposing personnel to harmful radiations

MESSAGE DEVELOPMENTS



▲ The arrangement of the apparatus nside the "Telecar." Directly behind ne driver's seat is the radio receivg equipment and to the right is the Telefax" message recorder by means f which facsimile messages are reproduced automatically

▲ The development of mobile radio-facsimile by Western Union resulted in "Telecars" for rapid delivery of telegrams in Baltimore, Md., where eight of these cars are operating

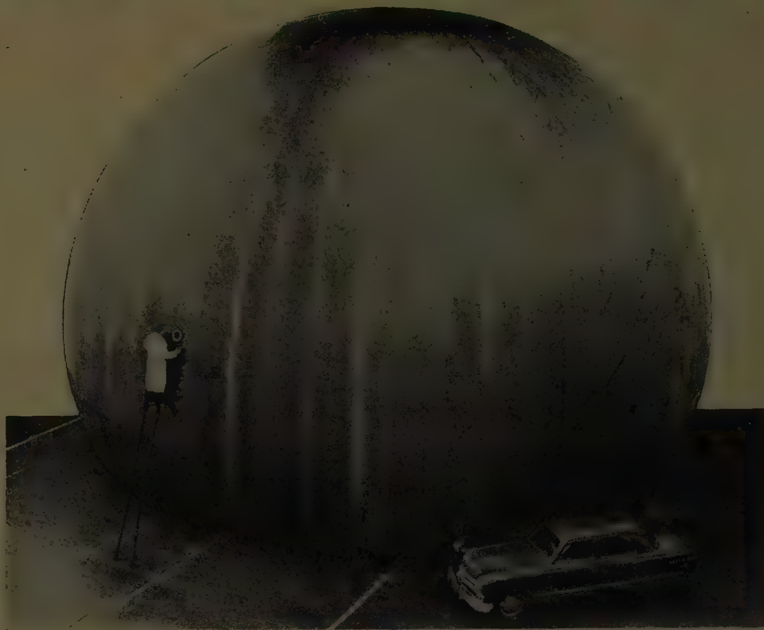


Lowering the new underwater nsatlantic cable amplifier off the st of St. John's, Newfoundland. It lanned to install ten similar amplis in the Western Union Company's er transatlantic cables, thus adding acity for 60,000,000 more words annually

▲ The telegraph receiving distribution racks at the Portland, Oreg., terminal of the Western Union's high-speed message switching system. The installation marks the completion of the initial phase of a nation-wide mechanization program under which such automatic equipment has been provided in 15 key cities

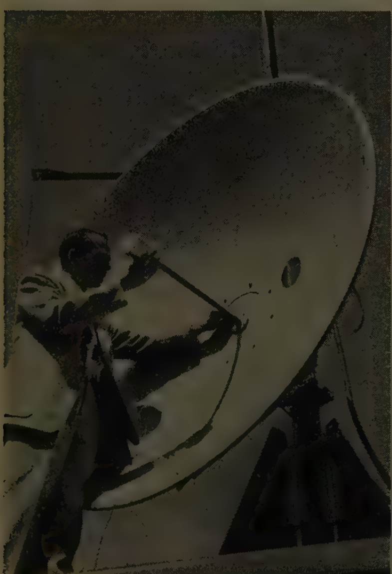
MICROWAVES

▼ Project engineer M. F. Davis finishes installation of a dipole in a reflector prior to making a test at Electronics Park, Syracuse, N. Y. One of the 114 microwave relay reflectors built for the communications system the General Electric Company is supplying to Transcontinental Gas Pipe Line Corporation, this will be part of the longest microwave relay system in the country. The system, extending over a 1,840-mile pipe line between Houston, Texas, and New York, N. Y., will be completed in 1951



Courtesy Watson Laboratories, United States Air Force

◀ Rubberized fabric domes are being made protect radar installati from the effects weather. The ballo like shelter, moun atop a 25-foot tower held up by 0.05 pou of air pressure with metal or wood suppo When inflated to pound of pressure, radome will withsta 125-mile-an-hour wi and, by flexing, shake off ice and sn Rayon, nylon, or Fib glas fabric, covered w rubber, makes the s of the radome which 167 feet in circumfere and 36 feet high



▶ This antenna pattern analyzer consists of a linear superheterodyne receiver covering a frequency range of 100 to 9,500 megacycles and a high-precision oscilloscope utilizing unique sweep and delay generators. The receiver is linear to 0.1 decibel over a 20-decibel range. The oscilloscope can be calibrated quickly to an azimuth display with an accuracy of 1 per cent of the displayed sweep. The instrument is completely portable, requiring no linkage with the rotating antenna under test; all rotational information is derived from the receiver output

Courtesy Watson Laboratories, United States Air F

A research program at United States Air Force Cambridge Research Laboratories has culminated in the development of methods of guiding electromagnetic energy by means of single surfaces in open systems. In the left picture are shown a spirally corrugated rod, a flat strip transmission line, and a circular corrugated cylinder. At the right is shown a close-up of a spirally corrugated rod and a circular corrugated cylinder

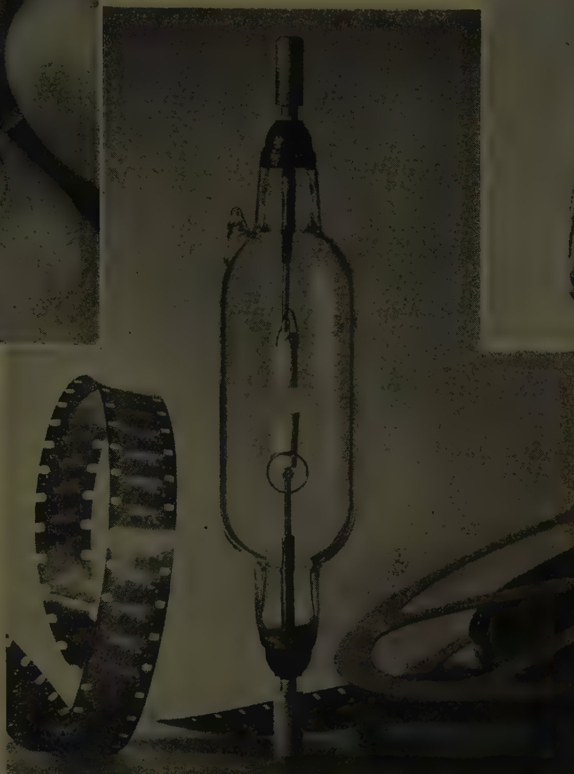
TUBES

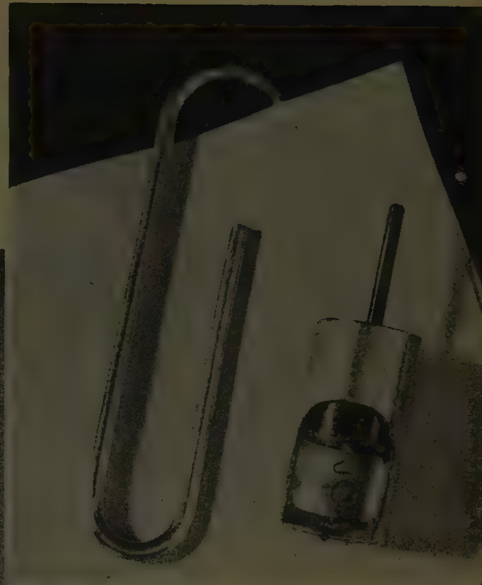
Courtesy General Electric Company

This ozone lamp, less than $1^1/_2$ ches in diameter, has been in- duced for use in the eradication many objectionable odors. The one produced by one 4-watt lb is sufficient to mask odors areas up to 1,000 cubic feet. erating on household current, is used with a ballast in a simple ture which shields the eyes from e ultraviolet energy generated the lamp. In addition to room odorization, it is being used in thes dryers and refrigerators

▼ This repeating flashtube produces clearer televised motion pictures at lower operating costs. Because little heat is generated, film may be stopped for focusing and adjusting

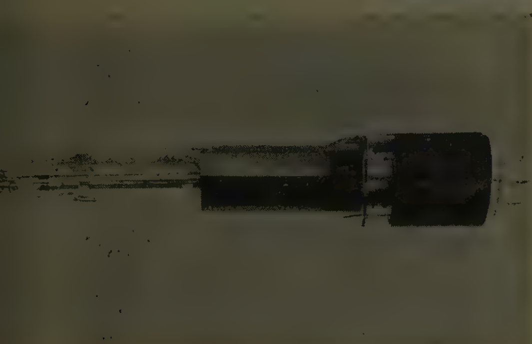
Courtesy General Electric Company





Courtesy Bell Telephone Laboratories

▲ The Phototransistor shown here operates like a phototube; it has a 0.003-inch-thick germanium crystal and a collector wire which control the flow of current



Courtesy Cambridge Research Laboratories
United States Air Force

A barrier-grid-type storage tube has been used to crease the signal-to-noise ratio of small repetitive dio signals; with appropriate circuitry, in elec- onic computers it can store up to 512 binary digits at the rate of one-half microsecond per digit

Dr. L. P. Garner directs the lowering of the anode- velope assembly into position on the Radio Cor- ration of America's new "Super-Power Beam iode." The 500-kw output capability of the tube due to the arrangement of the electron optical stems, which in effect concentrates 48 separate triodes in a relatively small space

NEW RESEARCH LABORATORY OF GENERAL ELECTRIC COMPANY DEDICATED

▲ Clues to crystal structure are revealed by this device called the X-ray spectrogoniometer. The machine, being used by Dr. W. L. Roth of the laboratory's Metallurgical Division, measures the angles at which a crystal scatters X rays. Research in this division includes study of behavior of metals, devising new alloys, and designing of electronic and X-ray apparatus for studying crystals

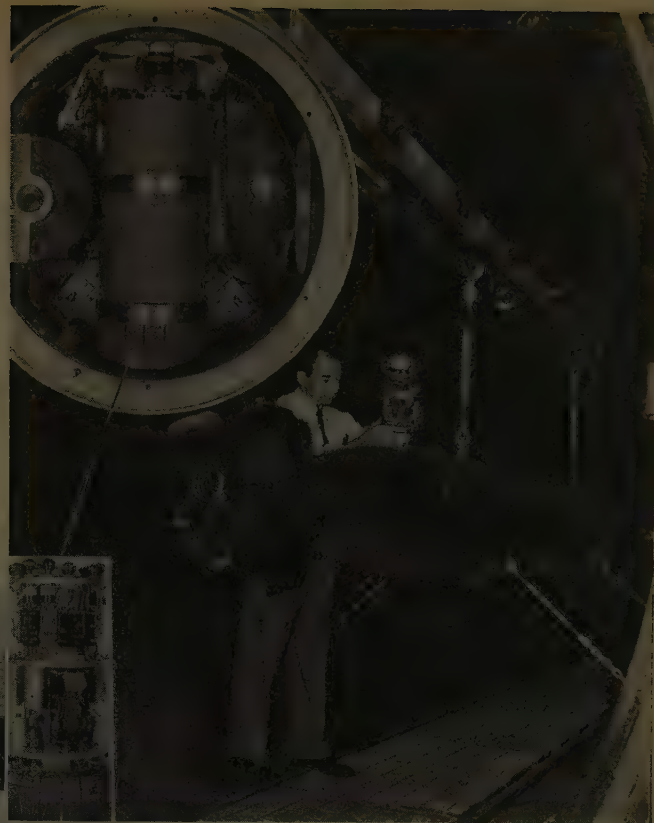
▲ The new General Electric Research Laboratory is located at th Knolls near Schenectady, N. Y. The main building houses 10 laboratory rooms, a 325-person auditorium, executive offices, office for weather research, and extensive shop areas. The building designed so that partitions can be moved to make laboratories of an size from six feet to the full length of the building. Other structure comprising the laboratory are the radiation laboratory, a low temperature laboratory, a chemical pilot plant, and a heating pla

▼ Typical laboratory room in the new Research Laboratory; this room houses investigations into the properties of metals. Work in the foreground is concerned with surface properties, in the middle area scientists are studying heat capacities of metals, and the group in the background is investigating changes in the structure of metals

▲ Dr. C. G. Suits (left), General Electric Company Vice-President in charge of research, demonstrates an experiment to visitors at the recent dedication of the new Research Laboratory. Spectators are (from left to right) Sir Lawrence Bragg, director of the Caven-dish Laboratory, Cambridge University, Cambridge, England; Professor Paul Scherrer of the Federal Technical Institute of Zurich, Switzerland; Charles E. Wilson, President of General Electric Company, and (seated) Dr. W. D. Coolidge, director emeritus of the Research Laboratory

Courtesy Allen B. DuMont Laboratories, Inc.

ingle-frame oscillograph-record camera employing Polaroid-Land process has been developed to give finished prints of oscillograms in one minute



In order to meet the demands for increased instrumentation during development and improvement of the underwater torpedo, engineers at the Naval Ordnance Laboratory at Silver Spring, Md., have devised a self-contained 6-trace high-speed recording cathode-ray oscillograph for recording performance during test runs of the torpedo

the Pressurized Ballistic Range of the Naval Ordnance Laboratory missiles be fired under pressures from 0.1 to 6 atmospheres. Spark shadowphs are made of the missile from any of 25 photographic observation stations

◀ With this Westinghouse fluoroscopic image amplifier, radiologists at Johns Hopkins Hospital, Baltimore, Md., are now able to distinguish between parts of the body which are mere outlines on ordinary fluoroscopic screens

▶ The permanent-magnet-type electron microscope should place electron microscopy within reach of most colleges, hospitals, and scientific and industrial laboratories. Permanent magnets are used to energize the magnetic field of this Radio Corporation of America product

CONTROL and INSPECTION

▲ The heater plug, indicated by pencil, is mounted o[n] the bimetal element of this new time-modulation ther[mo]mostat of the Minneapolis-Honeywell Regulator Company

An electronic statistical control indicator for the packaged-food industry developed by the Battelle Memorial Institute and the Exact Weight Scale Company indicates when the average package weight is out of control. The combined equipment operates up to 90 packages per minute and indicates corrections to the operator of the package filler when needed. Voltage signals from the indicator are used to adjust the package-filling machine automatically

▲ Approximately 500 ampules per hour can be inspected f[or] clarity with this photoelectric inspection machine develop[ed] by RCA for the American Drug Manufacturers Associatio[n] making possible legal standards of clarity for the drug indust[ry]

◀ This demonstration model of the quality control indica[tor] shows how an automatic continuous check is made on rej[ect] rates in manufacturing operations and makes possible the lo[ca]tion and remedy of abnormal production difficulties when th[ey] occur. This was developed by the General Electric Compa[ny]

POWER

The largest reversing twin-drive
t built for the steel mill industry
ng assembled at the General Electric
npany to replace a steam engine
a 206-inch 4-high mill. The new
t consists of two 4,000-horsepower
75-rpm 600-volt reversing motors,
connected to the top work roll and
other to the bottom work roll of
the mill

▲A saving in oil of about 50 per cent is effected by this new shape of oil tank of the interrupter assembly of Westinghouse's 7,500,000-kva 230-kv circuit breaker

▲ This 100,000-kva 3-phase fan-cooled transformer, the most powerful yet designed to operate at 138,000 volts, is being hoisted by a 250-ton crane from a test pit at the General Electric Company's Pittsfield plant. This is the first of four similar units being built for the Union Electric Company of Missouri and it required a special drop-frame car to carry it across the country

A 66-kv mobile unit substation which
lesigned for emergency or temporary
allation. The disconnect switch is
erated from outside the unfolded
tective fence and may be locked open
closed. This Allis-Chalmers trans-
mer is a 3,000-kva 3-phase 60-
le core type with a choice of 2,400,
00, 4,160, or 12,470 secondary
ts. Switchgear is provided with a
kv 1,200-ampere 150,000-kva circuit
reaker with auxiliary equipment

▼ A new rectangular explosion-proof 50-horsepower motor, which may be air- or water-cooled, was designed by Westinghouse for the continuous coal mining machines to replace the old techniques. The air-cooled 18 by 24 by 34-inch motor has corrugated sides; silicone insulation is used on the windings. The water-cooled motor is smaller and has a built-in heat exchanger of finned copper tubes carrying water on its way to wet down the coal face

1950 ENGINEERING DEVELOPMENTS

(*continued from page 7*)

instrumentation for the fuel supply, boilers, generators, and outgoing switchgear for a 40,000-kw 2-unit generating station.

ROTATING MACHINERY

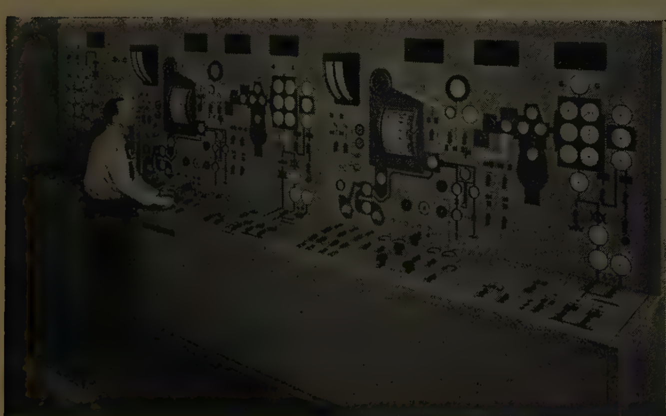
Of particular importance in the field of synchronous machinery has been the new information obtained in the matter of heat transfer, particularly with the use of fluids other than air.[1–4]

In the field of totally enclosed induction motors many developments have been made in the types of enclosures and means of ventilation of motors for generating stations.

A new insulation was developed for, and is being applied to, large high-voltage turbine-generator stator windings. This is a synthetic resin-bonded continuous mica-tape insulation which has a low power factor, high dielectric strength, and great voltage endurance coupled with unusual physical properties. Its physical strength is considerably greater than conventional insulations, and i is capable of elastic deformation and recovery to accon modate itself to the cyclic movement of iron and coppe under load variations.

Courtesy Westinghouse Electric Corporation

10,000,000-kva 230-kv tank-type oil circuit breakers installed at Grand Coulee Dam



Courtesy General Electric Company

Completely centralized control board for the Morgan Creek steam-generating station of the Texas Electric Service Company

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RELAYS

Reclosing Relay. A new circuit-breaker reclosing rela has been developed with new features which include 1. reset of the relay after any successful reclosure to elim nate needless delay in subsequent reclosures and reduc unnecessary lockouts; 2. a simple internal means blocking the instantaneous trip circuit after the initi circuit-breaker tripout to facilitate system sectionalizin and 3. immediate first reclosure through an initially close contact in the relay to reduce first-reclosure time.

Loss-of-Excitation Relay. A new relay has been mad available which is designed to eliminate one cause of syster disturbances. It is known as a loss-of-excitation relay type *CEH*. When a large generator accidentally lose excitation, this relay responds to the reversal of reactive current flow and takes the generator off the system befor it drops the bus voltage low enough to cause other ger erators to fall out of step.

A 1-Slip-Cycle Out-of-Step Relay. A new quick-actio relay, which will recognize an out-of-step condition in th first slip cycle and the relative direction of the slip, has bee developed recently. Rapid correction of an out-of-ste condition or removal of a machine from a system can b accomplished before a disturbance results in loss of load.

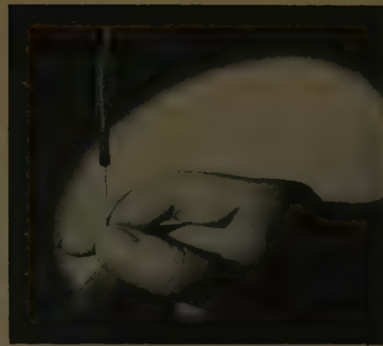
Voltage-Controlled Overcurrent Relays. More sensitive back up protection for a-c generators is provided with a ne voltage-controlled overcurrent relay which is a combina tion of an instantaneous undervoltage element and a time delay overcurrent element.

New D-C Relay. A new d-c relay uses a permanen magnetic field. It has higher torque than its predecesso yet its size has been reduced by almost one-half. It ca be used for various types of protection on d-c systems.

Distance Ground Relay. A new distance ground rela system has been developed which provides the man advantages of zone distance protection and eliminat most of the inherent limitations of the earlier forms ground distance protection. The new system consists a 3-zone distance relay, a selector relay, and a set auxiliaries. These two relays do the work of the thre relays required in earlier methods. The selector relay energized from zero-sequence and negative-sequence cu rent and selects the voltage of the phase faulted to groun to apply to the distance relay.

ariable Percentage Differential Relay. The variable per-tage characteristic for differential relays has been ved by many applications to bus protection. Now this nciple has been extended to transformer differential tection. The variable percentage characteristic pro-es protection against severe saturation of current trans-mers. The relay is relatively insensitive to magnetizing ush, yet provides a greater sensitivity to light internal lts than previous transformer differential relays. At same time, it has a wide margin of safety against in-rect tripping for external faults.

In the manufacture of this improved type of deposited resistor boron, as well as carbon, is pyrolitically deposited in a thin film on a ceramic core to give a product with a low temperature coefficient of resistance



Courtesy Bell Telephone Laboratories

Science and Electronics

ELECTRONICS

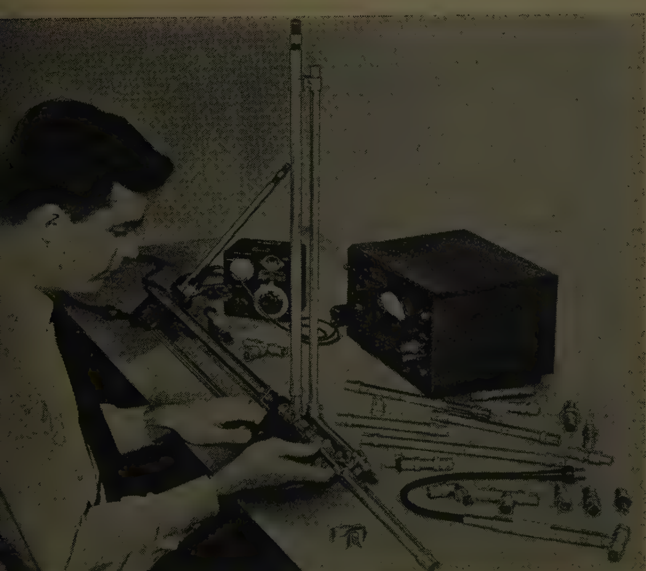
LECTRONIC METHODS and equipment have become very l widely adopted in recent years in practically all ds of electrical engineering. For this reason the more amatic new electronic developments of 1950 are probably greater interest to engineers whose particular fields power engineering, industrial applications, communica-n, and other applicational activities than to the men ose daily work is the engineering of the electronic equip-nt itself.

Microwave Applications.[1–3] The availability of dependable plifier tubes for use at frequencies of thousands of mega-les, together with increased experience in their use in amed microwave radio channels for point-to-point relay-of information, has led during the past year to a major rease in the manufacture of such microwave relaying uipment. The applications include communication ks for electric power systems, for transcontinental pipe-e installations, for studio-to-station links for radio and evision, and for remote control purposes.

Electronic Components; Quality Engineering for Computer es.[4–6] There has been a rapid and accelerating growth

Courtesy General Electric Company

The 4-foot probe of this new portable radiation detector enables the operator to measure radioactivity from a distance



Courtesy General Radio Company

uipment now is available for measuring impedance, standing-ve ratio, power, voltage, attenuation, and other quantities at frequencies from 300 to 3,000 megacycles

in the use of both analogue- and digital-computing equipment for the solution of problems in engineering design, in scientific research, in business and government statistics, and for military purposes. Electronic computing equipment requires maximum dependability as to length of life, precision, and quality in individual components. Also, the combination of excellent quality with minimum size is of great importance in order to conserve space, considering the enormous number of individual components necessary in a computer assembly. Thus, there has been a very substantial increase in the attention given to the engineering aspects of the design and manufacture of electron tubes, of passive components, and of assembly methods.

Electron Tubes for High-Frequency Industrial Power. There has been continuing emphasis on the modification of design of medium- and high-power vacuum tubes to make them peculiarly suited for use in the generation of high-frequency power in induction and dielectric heating, as contrasted

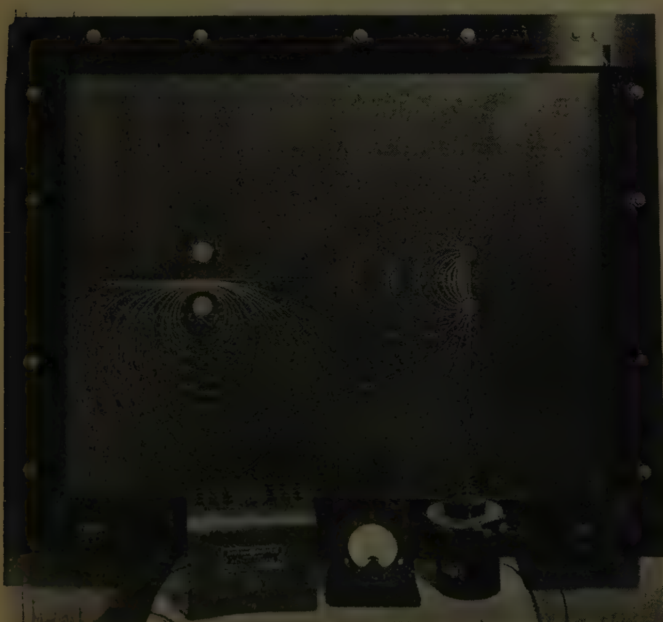
with early growth of design features, which were oriented entirely toward communication needs.

Radiation Detection Devices. In the field of gas tubes and of scintillation devices, there has been very rapid growth toward the perfection of devices suitable for faster response and greater sensitivity in the identification and counting of impulses due to the passage of high-energy particles.

Storage Tubes.[7] The growth of the digital-computer industry has placed increased emphasis on the need for an extremely rapid, dependable, nonmechanical memory storage device. As a result, major attention has been devoted during the past year to the development of cathode-ray tubes employing various forms of internal memory storage, as being the most promising avenue of attack in this problem of computer memory storage.

Semiconductor Devices and Applications.[8] This year has seen intense activity on the part of the electrical industry in the manufacture of semiconductor amplifiers, photosensitive devices, and point-contact rectifiers. This represents an extension from the original transistor development of two years ago. The most striking developments of the past year in this field have been the introduction of photosensitive semiconducting devices, a very large increase in the availability of germanium diodes, and the increase in engineering experience in the application of germanium diodes to high-speed switching phenomena in very complex circuits, as in the computer arts.

New Instrumentation Techniques.[9] The arts of measurement and control instrumentation are being improved continually and rapidly by the devising of new electronic techniques for sensing and responding elements. In particular, the past year has seen the introduction of the multiple Kerr-cell camera for the photographing of transient events at framing rates as high as 100,000,000 frames per second. Also, there has been developed an ion-scatterin analyzer which is applicable to the analysis of nonvolatil samples of materials in the form of a thin layer or a soli piece. It is reasonable to hope this can be very valuabl in the study of surface chemistry.



Courtesy General Electric Company

Field plotting device showing plotting board with conduction paper surface, power supply unit, microammeter, voltage divider, and field tracing prod

Electrostatic Processing. During the year and more imme diately past, there have been a number of significan engineering developments employing electrostatic processe for industrial applications. These include electrostati printing, electrostatic methods for dyeing fabrics, increase effectiveness in electrostatic precipitation, and electrostati sorting techniques. This is in many respects a completel new and very promising area of the electronic arts.

Magnetic Amplifiers.[10–14] The development of magneti amplifiers during the past year has extended rapidly an attracted much attention, and is becoming one of the ver important new frontiers in industrial and electric powe engineering. In many respects, magnetic amplifiers un doubtedly will replace electronic amplifiers and make i possible to use vacuum-tube amplifiers for controlling larg blocks of power, to an extent impossible if it were necessar for the primary power to pass through the electronic device

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INSTRUMENTS AND MEASUREMENTS

DURING 1950 there was improvement in design and i the quality of fabrication of both instruments an instrument components, and a greater selection becam available throughout the field. Typical of new develop ments and improvements in instruments and measuremen are the few specific developments mentioned here.

A special periscope to look at the 2,500-degree-Fahrenhe exhaust from the tailpipe of a roaring jet engine was de veloped by the General Electric Company. Eleven fe long, the periscope extends into the test cell augment

iiversal scintillation counter developed by General Electric Company for detection of alpha, beta, and gamma particles

be ten feet behind the jet nozzle. Consisting of an out-oor stainless-steel tube enclosing a water-cooled inner opti-l tube, the periscope permits observation of the pattern of ırning gases inside the engine. Its magnification of ree times makes possible an image the same as that which ould be obtained by the naked eye at a point close behind e nozzle.

Three kinds of radioactive particles—alpha, beta, and mma radiations—can be detected and counted with high ecision by a new instrument called the "universal scintil-tion counter" developed by the General Electric Com-ıny. It is designed for use in testing laboratory benches, oors, and equipment in radiation laboratories for radio-tive contamination, in measuring radiation from ore mples, and in determining how fast radioactive substances sintegrate. It can also be used in medicine and biology to tect the presence of radioactive "tracers," atoms tagged ith radioactivity so their movements can be traced. hen a sample is placed in the instrument's counting amber, radioactive particles strike a phosphor, a sub-ance which gives off light in the presence of radioactivity. hese scintillations of light then act upon a photomultiplier be, which converts the light into electric energy. A unting circuit then is activated by the amplified electric ergy to register the number of particles striking the phos-ıor.

A new full-view design in the type-*K-24* line of Circular-ale switchboard instruments was developed by the West-ghouse Electric Corporation. It has a new kind of dial id window construction which permits taking readings extremely wide angles, prevents shadows on the scale, id reduces glare. The new design is available for meas-ement of direct and alternating current, voltage, and atts, and for power factor, frequency, and synchronism.

A completely new line of pocket-size portable indicating struments for d-c and a-c applications has also been de-loped by the Westinghouse Electric Corporation; they have most of the features of larger size portable instruments, namely, fully insulated housings, regular insulated nut-type terminals, and magnetic shielding. The instruments conform to the new American Standard Association's *Standard C39.1*.

To meet the increasing trend towards kilovolt-ampere demand measurement, the Westinghouse Electric Corporation has augmented their line of kilovolt-ampere meters with a recently announced type-*KCA* thermal meter. This is a polyphase combination watt-hour and thermal kilovolt-ampere demand meter available for various polyphase circuits. Standard polyphase meter trim is used and the watt-hour elements are identical with corresponding 2-element watt-hour meters.

Reduction of current transformer errors to immeasurably small values has been accomplished by the Westinghouse Electric Corporation through careful application of the biased core principle in a new multiratio precision standard current transformer. This transformer, which introduces errors of less than 0.1 per cent and phase angle of two minutes at 100 per cent current over a range of burden from 1.0- to 3.0-voltampere burden, is used for meter calibration. One standard meter calibrated at five amperes is the only primary standard required.

Courtesy Naval Ordnance Laboratory

A new type of stroboscope, utilizing an electronic shutter, overcomes some of the basic limitations of flashing-light stroboscopes. By use of an image converter tube, an almost instantaneous picture (duration down to one-half microsecond) can be reproduced on a fluorescent screen

A new instrument, the Current Limited High-potential Tester, has been developed by the General Electric Company. It is designed for testing insulation of electrical components and assemblies such as coils, relays, motors, and appliances. Special applications of the instrument have been made for detecting flaws in surface coatings of paint, lacquer, and sheet materials of a nonconducting nature.

The *MH* (medium *H*) permeameter was designed by the magnetic measurements section of the National Bureau of Standards as a substitute for the Burrows permeameter which for many years has been generally accepted as the standard instrument for magnetic testing at values of magnetizing force up to 300 oersteds. It is an absolute instrument in the sense that its constants are derived from its own dimensions and, therefore, does not require calibration by comparison with any other permeameter. Its principal advantages over the Burrows apparatus are greater simplicity and ease of operation and the fact that it requires only a single specimen for test.

Significant developments during 1950 relating to instrument and industrial types of cathode-ray tubes are reported by the Allen B. DuMont Laboratories. For many years the cold cathode-ray oscillograph has been the virtual standard in the field of impulse testing. The type-*293* oscillograph has been developed with a sealed-off cathode-ray tube and a specially developed camera for external photography. High-speed sweep circuits of the order of 400 inches per microsecond and amplifiers with a gain of about 3,000 and bandwidths of 150 megacycles were developed. New oscillograph record cameras transform the cathode-ray oscillograph from an indicating device to a measuring and recording instrument. Among industrial-type tubes, developed during the past year are a new flat-faced 3-inch tube and a new 5-inch tube with increased sensitivity and low deflection capacitance for use in wide-band amplifiers.

Courtesy Bell Telephone Laboratories

50-kc to 20-megacycle phase, delay, and transmission set for accurate measurements on new coaxial transmission systems

In the development and manufacture of components and equipment for new coaxial transmission systems, accurate measurements must be made at frequencies up to 20 megacycles. For this work, Bell Telephone Laboratories has developed a 50-kc to 20-megacycle phase, delay, and transmission set. The frequency may be set manually or swept by a motor drive through any band. Many refinements are employed to reduce measurement time and to avoid errors. Accuracy is of the order of 0.1 degree, 0.01 microsecond, and 0.02 decibel.

The importance of conductivity in the performance of microwave apparatus has been receiving increased attention. A method of measuring conductivity, featuring accuracy and convenience, has been developed by the Bell Telephone Laboratories for operation at 9,000 megacycles. Small wire samples form the center conductor of an open-ended coaxial line whose Q can be determined and related to the desired conductivity.

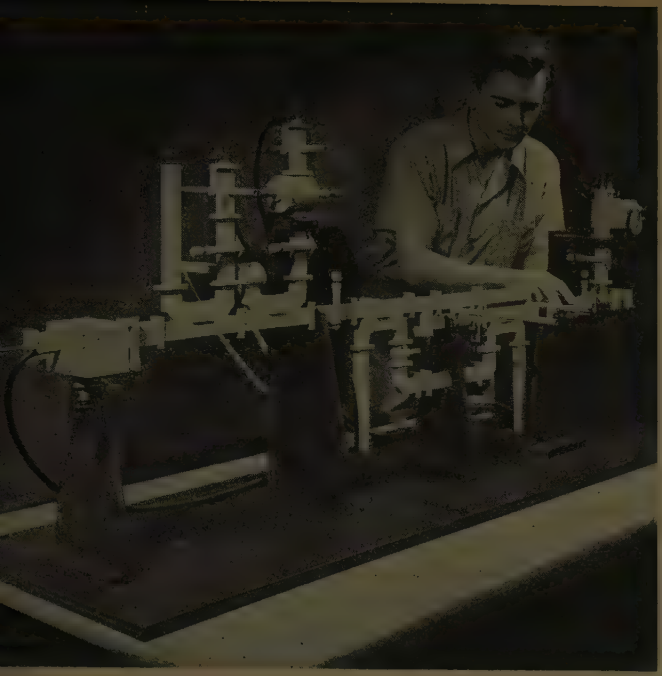
A new concept for the design of voltage dividers for short impulses or for ultrahigh frequency was presented. It showed that capacitances and inductances, when properly placed in a voltage divider, make it capable of passing all frequencies and transients without phase shift or distortion.

A new direct-reading impedance-measuring instrument for the ultrahigh-frequency range was announced this year by the General Radio Company. The need for direct-reading measuring equipment at high frequencies is increasingly evident. It has been found that lumped-parameter elements generally cannot be used satisfactorily in conventional bridge circuits above about 150 megacycles and that new arrangements based on coaxial line techniques offer greater promise. The General Radio type-*1602-A* Ultra-high-Frequency Admittance Meter is a null device based on these techniques.

Refinements in design and manufacturing techniques extending the frequency range of conventional low-frequency bridge circuitry to 165 megacycles are also reported by General Radio.

The General Radio type-*1000-P6* Crystal Diode Modulator makes available a means of wide-band modulation for television, conventional standard-signal generators, or oscillators. A new 2-Signal Audio Generator provides a basic tool for audio-frequency development and research and should accelerate progress in understanding the significance of intermodular distortion and its relation to subjective listening tests.

An electronic instrument recording on a chart the number of components in each lightning stroke within a 20-mile radius was developed by the Hydro-Electric Power Commission of Ontario. The instrument assists in establishing operating requirements for high-speed reclosers and the like. The Commission also built a device for measuring the relative shaft angle of two synchronous generators removed



ircuit for measurement of conductivity at microwave frequencies which has been developed by the Bell Telephone Laboratories

om each other by 100 miles, for example, to indicate angu- r changes in relative shaft position as small as a few inutes of arc. Further, the Commission reports the con- ruction of a portable photoelectric photometer for low vels of illumination, designed primarily for measuring the orizontal illumination on streets.

The Subcommittee on Industrial Spectroscopy cites as gnificant developments this year in the spectroscopy field e following items: Baird Associates has announced an ectric analogue computer to solve problems of atomic dilu- on in the spectrographic analysis of high alloys; The Ap- lied Research Laboratories of Glendale, Calif., have intro- uced changes in their Quantometer allowing the imme- iate analysis of any one of up to three basic materials, for xample, aluminum, zinc, and lead alloys; the Jairell-Ash ompany has modified its comparison microphotometer y increasing sensitivity with a *931A* photomultiplier tube s the detector and to protect against line voltage fluctua- ons—the phototube sensitivity, through its power supply, varied inversely as the intensity of the light source.

A new electric control system has been developed by eeds and Northrup Company. A control slide wire actu- ed by the recorder, which measures the controlled quan- ty, provides the error signal to the control system. The ntrol unit provides proportional reset and rate actions rough the use of circuits utilizing resistance-capacitance etworks of long time constants. A high-impedance de- ctor responds to the network balance and actuates a otor drive unit which operates the control element.

A novel long-distance telemetering and control system r four new pumping stations on a pipeline of the Shell Oil ompany was designed and put into service by the Bailey leter Company in collaboration with the General Electric ompany. The system provides that by dialing a number character in the control station the desired intelligence (motor current or pump pressure) from one of the unattended pumping stations will appear in a few seconds on the control station's teletype receiver.

Direct solution of many theoretical and practical problems in the electrical, mechanical, thermal, or hydrodynamic fields has been simplified by an instrument recently developed by the General Electric Company. Consisting basically of a thin sheet of graphite impregnated paper, 6-volt d-c power source, voltage divider, sensitive microammeter, and potential exploring stylus, the instrument offers graphic solutions by simple analogy methods. Patterns to be established can be controlled by metallic electrodes, silver conducting paint, or cutout areas on the paper with boundry conditions in accordance with the problem. Equipotential lines on the paper are located with the stylus by a series of punch marks at zero readings of the microammeter, and later can be intensified with white ink.

Ion pulse techniques for measuring the velocity of air flow are utilized in an "air marker" developed by the General Electric Company. This instrument is designed for use in locations inaccessible to conventional air velocity measuring devices. It will measure velocities of air streams covering a range from gentle air currents in a room up to those of sonic speed.

High-precision measurements in the low mass range are being made successfully at the National Bureau of Standards and in the General Engineering and Consulting Laboratory of the General Electric Company by means of a new type of ion resonance mass spectrometer tube. In this ion resonance tube, electrons from the filament are accelerated and form ions which are in turn accelerated in a space where crossed magnetic and radio-frequency electric fields are maintained. Those ions with the proper mass to resonate with the crossed fields will gain energy and describe larger and larger orbits until they reach the collector and are measured. By varying the field it is possible to collect and measure in sequence the ions of various masses.

BASIC SCIENCES

DEVELOPMENT and use of ferrites as magnetic core material, especially for high frequencies, is expanding rapidly. The concept of magnetic domains is now definitely established. Such domains can be seen under a microscope and their changes with magnetization thus observed.

In the field of the electrical properties of solids and liquids, the introduction of the germanium transistor has aroused interest as shown by the number of papers covering developments in the semiconductor field.

Electric circuit analysis is always an interesting problem to the engineering profession and the developments in this field continue apace.

One significant development in the field of electric properties of gases has been the production of arcs with exceptionally low voltage drops.

The application of mathematics in engineering received new impetus in the formation of a joint subcommittee of mathematicians and engineers for the solution of problems arising in electrical engineering.

Progress in the development of energy sources is most pro-

Facilities for testing products under subzero conditions have been put into operation by the Hobart Brothers Company, Troy, Ohio. A technician is shown testing an arc welder at −65 degrees Fahrenheit

nounced in the design of special-purpose batteries, developed by the United States Signal Corps, which are extremely light and of superior performance, particularly at low temperatures.

POWER CONVERTERS

IMPROVEMENTS in vacuum techniques have made possible the development of a new type pumpless ignitron. This metal tank rectifier is of demountable construction so that it may be reconditioned readily. However, a high order of vacuum tightness is obtained by means of new sealing techniques, and the tank is so thoroughly degassed that it will maintain vacuum for many years of service.

Heretofore, large mercury-arc rectifiers have been of the pumped type with each tank connected to a manifold and continuously evacuated by vacuum pumps. The pumpless ignitron provides a sealed unit without pumps in the larger sizes and supplements the smaller sealed ignitrons. A unit consisting of six pumpless tanks has been operating successfully in service for over two years.

Three important improvements have been made in the mechanical rectifier during the past year, which will improve performance greatly and decrease maintenance problems.

1. A new contact assembly, containing stationary and moving contacts and spring, factory assembled in a moulded block, has been introduced. Nine screws and clips hold the six assemblies. If necessary, all six contacts could be replaced easily in five minutes.

2. Each screw provides timing adjustment for one con-tact. This adjustment can be made without shutting down while observing commutation on the oscilloscope under ac-tual load conditions.

3. Means have been provided for automatically and continuously adjusting the time of contact separation within the "Break Step," so as to accommodate safely the maxi-mum range of sudden load changes under all operating conditions.

These improvements are being incorporated in rectifiers currently under construction, totaling over 16,000 kw.

Industry

ELECTRIC WELDING

THE LAST YEAR has seen more of a consolidation of gain in the welding field than of any special new develop-ments, but the commercial acceptance constitutes definite development.

In arc welding, the trend is toward greater application of automatic equipment. The continuous process that uses inert gas to shield the welding field, and still feeds in filler material, has been refined until welding is possible at speeds well beyond previously accepted limits. In similar vein, a submerged (flux) arc method has been developed to the stage where the bulky accessories that attend the cur-rent and flux contributions to the point of work are placed well away from the actual arc. This permits a degree of

Courtesy Westinghouse Electric Corporatio

Resistance welding of thick aluminum sheets has been difficul because the great heat conductivity of the aluminum allow heat to flow away so fast that poor welds result. Recently th Thompson Electric Welder Company has welded 1/8-inch shee aluminum experimentally

xibility in welding through small openings and within nall enclosed quarters that has never been possible before. method of welding through 5/8-inch plate also has been veloped, permitting complete penetration in horizontal eld joints on vertical planes of bridge work, tanks, and so rth.

The resistance welding field has been marked by realizan of the importance of maintaining pressure on spot-and-ojection welds continuously during the actual melting of e metal. Toward this end many mechanical improveents have been made in machines, but much of the improvement has come from electric controls and power supy. By feeding power into the weld at a controlled rate om instant to instant, many of the limitations caused by achine inertia and friction have been overcome. Also, is year marked the use in production of the most electrical resistance welders: one in which the welding force is ovided magnetically by the welding current, permitting eat improvement in projection and spot welding, particurly of nonferrous metals including silver and copper.

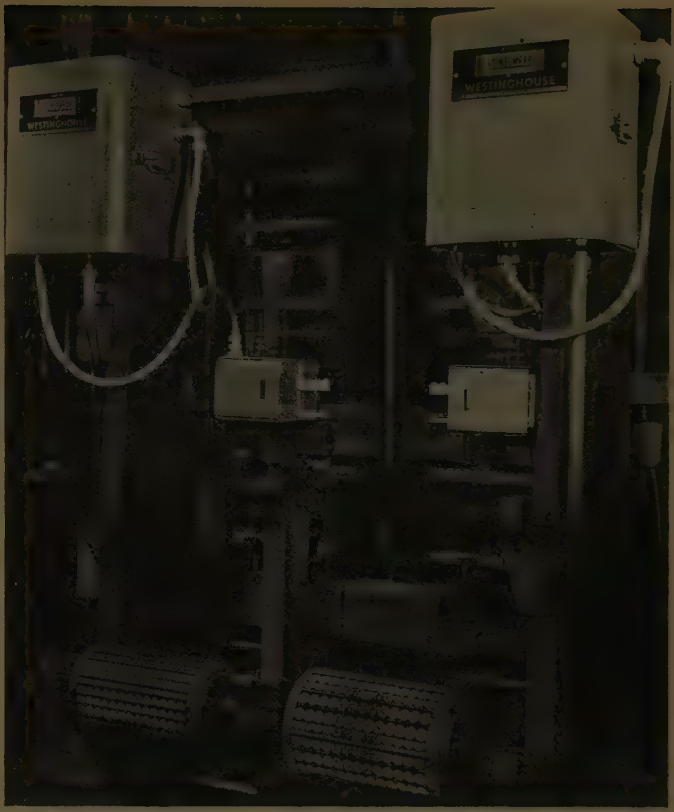
CONTROLLERS

A NEW LINE of high-voltage high-interrupting-capacity "Limitamp" controllers which are capable of interpting available short-circuit power up to 250,000 kva has en developed by the General Electric Company. Panels e rated up to 2,500 horsepower at 4,160 volts, and they ay be used on systems up to 4,800 volts. The use of 400-npere air-break contactors and current-limiting fuses ovide a co-ordinated motor starter. Designs are availle for full-voltage starting, reduced-voltage starting, dymic braking, reversing, multispeed control, and combitions thereof.

A new line of preset-speed printing press controllers also as developed by the General Electric Company. Preset eed control is provided, including starting, jogging, jog versing, slowdown, and plugging functions, by means of motely located push button stations. Uniform starting rques and slowdown speeds are obtained regardless of the eed controlling rheostat position; 72 printing speeds and ree slowdown speeds are available, which are adjustable om outside the enclosure.

A new simplified control for calendars and auxiliaries hich combines magnetic and electronic control has been veloped by the General Electric Company. A considerle saving in space has been effected over previous designs. ne main calendar drive is an adjustable-voltage controller th an electronic speed regulator. Identical rectifier units pply both motor and generator fields. A new type of s-filled thyratron reduces warm-up time to one minute d eliminates the need for forced ventilation. Adjustablene acceleration and deceleration, stepless speed control, curate speed regulation, jogging, threading, reversing, d regenerative braking are functions performed by this ntroller.

A type-*PR-12* register regulator for Stokeswrap wrapping achines was developed by the Westinghouse Electric Corration. The wrapping material passes between the nner housings where a printed register mark generates electric signal which is transmitted to the register regu-



Courtesy Westinghouse Electric Corporation

A register regulator for a Stokeswrap wrapping machine installed on a wrapping machine at the National Biscuit Company

lators. The register regulators control the movement of the wrapping material to insure that the sealing and cutoff operation occur at the proper point on the package.

For quick stopping of a-c motors, a starter, using a newly developed circuit that produces good electrical stopping characteristics without the usual requirements of a d-c source or the usual transfer switching that first removes the a-c power and then applies the d-c braking current, has been developed by Cutler Hammer, Inc. A half-wave rectifier of suitable characteristics is by-passed by the starter during running. When the starter opens the rectifier is instantly in the circuit and supplies half-wave pulses to the stopping network in a manner which produces braking torque.

ELECTRICAL HEATING

IN THE glass-melting field, submerged water-cooled molybdenum electrodes to utilize direct resistance of the molten glass have apparently overcome the problem of discoloration of the product. Fairly wide application has been made, often in conjunction with oil or gas fuel, thus securing close control of heat for the refining period. Current control by saturable reactors gives excellent results.

In the production of continuous-welded tubing or pipe from strip, induction heat has given two to three times the former production using resistance welding. Using hot-rolled strip, an installation of 10,000-cycle equipment is giving 200 feet per minute production of 3/4-inch thin-wall conduit (0.050-inch wall) at 270-kw power input.

Adrenocorticotropic hormone (ACTH) manufacture has

been speeded to ten times previous rates by using special resistance wire grids on "Tefloglas" (woven glass and Teflow) frames to provide infrared radiation for drying at low ambient temperatures.

A Pyrex *E-C* (electrically conductive) radiant panel which incorporates a thin transparent conductive film on one side of a glass panel has been made available for infrared heating by the Corning Glass Works. With suitable contacts and mounting frames this versatile piece of heating equipment is being experimentally applied on a wide variety of heating and drying jobs.

General Applications

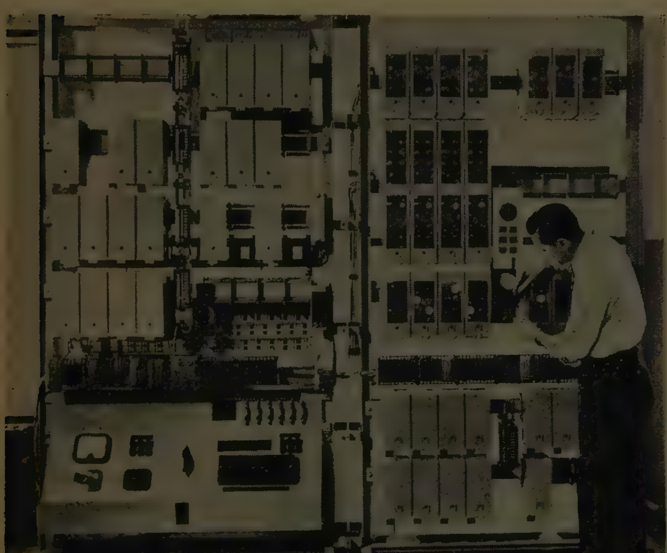
LAND TRANSPORTATION

PROGRESS has continued during the past year in the development of electric apparatus and equipment for land transportation uses.

In the heavy traction field the continuing substitution of Diesel-electric locomotives for steam locomotives has continued at an increased rate, and on some railroads the steam locomotive has been eliminated entirely.

Further experience in commercial service has been obtained during the year with the gas-turbine locomotive mentioned in last year's report,[1] and one more locomotive of this type is being used by another manufacturer.

The use of the mercury-arc rectifier, mentioned in last year's report[1] as applied to a motor car on an a-c electrified railroad, has been successfully continued during the year, giving promise of further application of this type of motive power. Orders have been placed and construction has been started for two locomotives having such rectification equipment for use with d-c traction motors for a large eastern carrier electrified with alternating current.



Courtesy International Telephone and Telegraph Company

One-sixth of the behind-the-scenes equipment of the Intelex System, the new electronic reservation equipment installed by the Pennsylvania Railroad in New York. The system, which retains human contact between the public and the railroad by way of ticket sellers and reservation clerks, utilizes some of the principles of the dial telephone, magnetic recording, printing telegraph equipment, and automatic bookkeeping

Continued progress has been made both in the heavy traction and light-traction field in the development of lightweight traction motors and associated control equipment. Both the New York Central and the Pennsylvania Railroad have placed in operation during the year new multiple unit motor cars having a new design of truck with a light weight high-speed motor with flexible drive. The truck design in each case is similar, one having a-c motors and the other d-c motors. In the light traction field the principle of the lightweight Presidents' Conference Car (PCC) has been extended to some rapid transit lines using cars with multiple-unit operation in trains. These new cars are also distinguished by their lightweight control equipment.

Electric business machines and electronic devices in the various intricate accounting systems have been introduced by railroads, particularly devices for rapidly recording the advance registration of Pullman car space on certain large carriers. A very interesting train-performance calculating device has also been developed during the past year.

Reference

1. 1949 Engineering Developments, AIEE Committee Report. *Electrical Engineering*, volume 69, 1950, page 8.

ELECTRIC APPLIANCES

THERE HAS BEEN a very rapid growth in the use of electrically heated motor-operated laundry dryers. These units ranging in rating up to 4.5 kw may, in the opinion of some utility companies, produce a load comparable to the electric range load.

Automatic clothes washers continue to grow in popularity constituting in 1950 35 per cent of all washers sold compared to 20 per cent in 1948 and 29 per cent in 1949. A new development in clothes washers has been the use of a flexible rubber diaphragm in the shape of a tub which, after the washing operation, is collapsed over the clothes by evacuating the air and water to extract the moisture. An ingenious combination air-and-water pump is involved.

A new application of Alnico magnets is the magnetic gasket for refrigerator doors. A hollow extruded plastic gasket, which makes a thermal seal between the door and the cabinet when the door is closed, contains a large number of small tubular magnets which hold the door closed and so eliminate a latch. They are polarized in pairs to accentuate the cross field. By distributing the pull around the periphery of the door an excellent seal is obtained and yet only a small hand pull is required to open the door.

In the field of heat pumps development has continued and the number of installations has been greatly increased although this application is still in its infancy. About 750 installations are operating, 60 per cent residential, 40 per cent commercial. Several new manufacturers have put out field trial installations in various sections of the country and much valuable technical data has been collected. There has been further research into the problems of heat sources, water, ground, and air, and in the problem of heat storage. Among suggested applications are domestic water heaters and orange juice concentration.

Industry Appraises and Develops the Engineer of Today

EVERETT S. LEE
PAST PRESIDENT AIEE

Industry and engineering are dependent on one another. What the young engineer can give to industry and get from it is discussed by Past President Lee.

PEAKING TO a House of Representatives Monopoly Subcommittee recently, Benjamin F. Fairless, President of the United States Steel Corporation, told the nmittee that United States Steel "...is successful, it is ofitable, it is efficient, and it is a large enterprise. These the simple facts and I am proud of them..." I think can all thrill with Mr. Fairless in his pride, and I believe statement can be applied to all American industry ich has built the greatest industrial nation on the face of earth.

And in this achievement the engineer can well be proud, in back of all the construction of industry stands the civil gineer, in back of all the industrial metallurgy stands the ning and metallurgical engineer, in back of all the manery of all industry stands mechanical engineer, in ck of all the chemical ocesses throughout industry nds the chemical engineer, d in back of all the electric wer and machinery and hting and communications ich move and direct industry stands the electrical engier. Every material thing we have has behind it a rounce of engineering and industrial achievement. This he contribution of the engineer to the service of mankind. is is the contribution of the engineering profession.

The length and the width and the breadth of this conbution cannot be totally realized because of its enormous gnitude. Go with me wherever you will in this great intry of ours, and there you will find industry giving rk to millions of our people to sustain them and to give em the satisfactions of life. And wherever you find instry, you find the engineer. Industry has appraised the eatness of the engineer as it has recognized him as the one o fashions the knowledge of the universe into products for people to have and to use. And as industry has built to greatest of heights to produce these products, so has the gineer been provided by industry with the sinews to velop his contributions until they have become the great- of wonders in every avenue of life. Industry owes all to engineer and the engineer owes all to industry, for m his study, from his hard work, from his knowledge, m his ability, from his vision, from his unfailing fervor accomplish the impossible and to produce the new, there ve been brought forth all of the products for our people to ve and to use.

Industry stands today entwined with the engineer. He rmeates its entire fabric. He has grown with industry be among its leaders. He is established throughout industry in the development and design of its products. He directs the processes of industry. He establishes the tools of industry. He installs and operates the services of industry. And he sells the products of industry. Take him from industry and industry would collapse. And in so far as government includes the engineer within its operations, the same applies.

Each year the engineering schools of our land bring to industry the young engineers who would enter industry to add their contributions to the endless procession of engineering achievement which undergirds our ever increasing standard of living.

The young engineers can expect to find that industry will be looking to find in them those same qualities which have characterized the engineers who have entered before them. Men who are honest, men who are loyal, men who are reliable, men who are dependable, men who have knowledge and understanding of the phenomena involved, men who can conceive of the new and who have the wisdom and the courage to carry it through to successful accomplishment, men who are enthusiastic in their work, men who know how to work with other men, men who are leaders, men who have knowledge beyond the usual, men who have skill beyond the skillful, men who have judgment as to action, men who have wisdom as to compromise, men who respect human endeavor and human safety, men who have personalities that are pleasing and inspiring, men of character who live righteously to serve their fellow men with distinction. These are what the men of industry look for in those engineers newly coming to their doors. These are the characteristics of the engineering profession. These are what are expected of the engineer.

It is a great tribute to the engineering schools of our land that they have provided for the young engineer, as he associates himself with his teachers and his fellow students, the opportunity for him to weave into his life these attributes in so far as he is able. Industry, as it has developed more and more from the contributions of the engineer, and as the engineer has developed more and more from his own contributions, expects more and more from the young engineer. And from our engineering schools he should be equipped with the fundamentals to meet this greater expectation. But the development does not stop at entrance

Full text of an address presented at the AIEE Middle Eastern District Meeting, Baltimore, Md., October 3–5, 1950.

Everett S. Lee is executive engineer, General Engineering and Consulting Laboratory, General Electric Company, Schenectady, N. Y.

to industry. Rather it is accelerated and focused in a myriad of ways to the accomplishment of the multitude of outputs demanded from industry. To this acceleration and focus the young engineer must learn to adapt himself, and industry's appraisal of him will result from his success in his adaptation to his new work, from his progress in his new work, and from his accomplishments and contributions as he advances daily.

While the basic fundamentals of all industries are generally the same, the detailed organization arrangements and concepts differ greatly throughout industry, as is to be expected where our greatest fundamental in this country is freedom and where a multitude of considerations come into each individual industry situation to govern the result. Thus the young engineer will have to ascertain these individual characteristics and to evaluate them as they apply to his individual ability, to accept them and live along with them, until as he lives with them he becomes a part of them, and with the increase of days he finds himself in a position where he is contributing to their direction. And so there is the period of training. The engineering and industry publications are full of descriptions of these periods of training. Here the young engineer can appraise for himself the consideration which industry gives to him in his initial years. And where it is substantial he can know that the concept of the engineer is good throughout the further years of his engineering life. He also has the knowledge that he becomes a contributing part to the whole as he advances, and that he can play his rightful part in shaping it.

The early years of engineering training in industry, while offering every opportunity, are often long and hard and sometimes wearisome. There is the discipline of learning to adapt oneself, and the transition is usually so abrupt that the way seems hard, but if the young engineer will continually keep in mind the fundamental that his is a great opportunity because of what has been built before him, often extending over many years and including many people, he will realize its need and its reasonableness and will master it as quickly as possible so that he can put his energies into moving onward to apply himself to the new that needs to be accomplished. The unsolved problems of today in engineering outnumber the solved. Thus there is for the young engineer as he begins to establish himself in industry the opportunity to apply himself to the unsolved problems which are waiting to be solved. And if he can give promise to solve them, he will find industry ready to provide him with the means for so doing, and usually much beyond his own ability. Thus the young engineer develops, hand-in-hand with industry, and his appraisal by industry is in accordance with his development and his contributions. As he grows into positions of responsibility and trust he, in turn, will be helping to develop the engineer younger than himself and to appraise him. Thus his engineering life progresses. And with it come the friendships of his fellow engineers and his associates. These are what make his engineering life a joy, and these he must not neglect, but these he must cultivate.

Now, just as everything else in life has an independence and a dependence, so does the engineer have an independence and a dependence. The world needs engineers for engineering. Engineering is the independence of the engineer. This is his great responsibility in life. It is in the doing of it substantially and superlatively that progress results. That the engineer has applied himself to his great responsibility is shown by the industrial structure that has been built and the output that has resulted. In this he has been truly successful.

Then there is the dependence of the engineer upon his fellow men. From the scientists he obtains new knowledge which he molds into new products for our people to have and to use. From the great leaders of industry has come the industry of which he is a part. From the workers in the shop is provided the proficiency of hand and of eye to turn out in massive numbers the products he has developed. From the services groups come the services he requires. And the salesmen and the merchants arrange the products for the people to see so that they may exchange their dollars for the satisfactions which the products bring. And thus the products of the engineer get to the people for their use and enjoyment. This is a long and a noble procession.

Then there is another group entwined in this procession. There are the doctors who keep us in good health; the lawyers who keep us in line and keep us out of jail; the bankers who provide the wherewithal to give us a start and to help to keep us going; the farmers who provide us with our food; the entertainers and the sports people who give us enjoyment; the ministers who guide us in paths of righteousness; the statesmen who lead us in government; the politicians; the men in the Services who protect us from the enemy; and the school teachers and those at home who teach us all and bring knowledge and understanding and wisdom everywhere to the young people entering the entire procession to keep the whole continuously supplied.

The result in this great country of ours is what we have all done together, and the engineer is in the forefront of the procession. His independence is fundamentally that he opens new doors. His dependence is his concern that the procession through the open door is for great good.

And thus industry appraises the engineer. And thus the engineer develops with industry. His appraisal is great as his contributions are great. He has increasingly developed as he has used the sinews of industry for his development. And he has built well.

In the words of Ruskin: "Therefore, as we build, let us think that we build forever. Let it not be for present delight, nor for present use alone. But let it be such work that our descendants will thank us for. And let us think as we lay stone on stone, that a time is to come when these stones will be considered sacred, because our hands have touched them, and that men will say as they look upon the wrought substance of them, 'See! this our fathers did for us.'"

Our greatest need today is for understanding and wisdom to use wisely what we have built so that there will be an understanding by all men of the fundamentals which have created it, and to what purpose, in order that there may be wisdom in guidance and direction and leadership so that what has been built will be understood to be for the good of all men.

Microwave Applications to Bonneville Power Administration System

R. F. STEVENS
MEMBER AIEE

T. W. STRINGFIELD
MEMBER AIEE

The development of microwave radio has presented the power industry with a valuable tool for transmitting many types of intelligence. It is now being applied to the communication system of the Bonneville Power Administration, since the use of power line carrier by it and ten major interconnected power utilities has almost saturated the available carrier spectrum.

THE MERITS of microwave radio as a backbone for the communi-ations system of a large ower utility are now being ut to practical test by the onneville Power Adminis-ation (BPA). There is be-g placed in operation a 200-ile link consisting of eight ations, while work is under way on additional links otaling 660 miles with 27 stations.

Until recently, the communication needs of the Ad-inistration had been served, somewhat inadequately, y conventional power line carrier. Rapid power system xpansion, under way and projected, made it clear in 946 that a corresponding expansion of communication cilities could not long be postponed.

It was natural that microwave, then newly developed, hould be given a prominent place in the studies which ere undertaken to work out a long-range communica-on program. These studies were comprehensive in their ature and considered all available types of channels.

No single type of channel was found to be superior for l applications. Each type was found to have some job hich it could do best in an integrated system.

Toll and Exchange Service. It was obvious from the start at a simple extension from the nearest telephone com-any exchange was the sole solution needed for many of e small unattended stations. Toll calls from such ations are so infrequent that costs are generally less an the annual cost on the investment which would e required for facilities to connect to the government stem. Reliability and speed of service are generally lequate for a station of this type.

Toll and exchange service is also desired at the larger ations for communication to points not reached by the overnment system. It will not constitute the sole or rimary communication to such stations for operating urposes, however. The importance of most such stations emands at least two alternate methods of communication, least one of which is not so susceptible to storm damage open-wire telephone lines.

Leased Wire Circuits. Leased wire has economic advantages when used over short distances, particularly in urban areas. It has been used for pilot-wire relaying and telemetering. It is also used by some of the interconnected power utilities to provide connections between their dispatcher and the Bonneville communication system.

In many cases the reliability has been disappointing. Open-wire phone lines, and even cables, are more susceptible to damage from storms, floods, and other disasters than the rugged transmission cables used with power line carrier.

All studies indicate that leased circuits are not competitive in cost with power line carrier over long distances. The same has been found to be true as compared to microwave, when the latter is properly applied.

Government-Owned Wire Lines. Because of susceptibility to storm damage and high maintenance cost, no government-owned wire lines are presently planned. Short sections of underground communication cable will be used, however, between substations and nearby microwave stations for distances of about a quarter of a mile.

Medium-Frequency Radio. Medium-frequency radio is used by the Administration for communication between fixed stations and mobile units, and has generally been satisfactory. However, because of skip-distance effect, the coverage of the region is somewhat erratic, and occa-

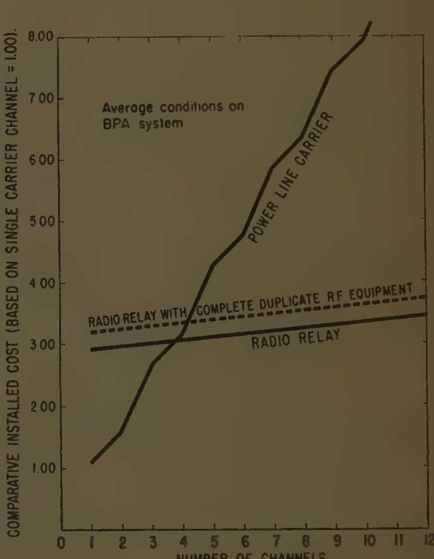


Figure 1. Cost comparison of power line carrier versus microwave for average conditions on the Bonneville Power Administration system

ential text of paper 50-170, "Microwave Applications to Bonneville Power Adminis-tion System," recommended by the AIEE Committee on Carrier Current and ap-oved by the AIEE Technical Program Committee for presentation at the AIEE Sum-r and Pacific General Meeting, Pasadena, Calif., June 12–16, 1950. Scheduled for blication in AIEE *Transactions*, volume 69, 1950.

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Figure 2. Communication facilities for the Pacific Northwest Federal power system with proposed extensions through 1954

sional cases of interference have occurred. This is essentially a one-channel system and will not be adequate when activities become more extensive. Also, the amplitude-modulated equipment is susceptible to power line noise. The medium-frequency equipment is also limited in point-to-point communication for emergency use only and cannot be used for routine operations.

Very-High-Frequency Radio. Very high frequencies, because of their short range and fewer license restrictions, will overcome these disadvantages, and the Administration plans to use them in the future for fixed-to-mobile communication. Very-high-frequency equipment is normally frequency-modulated and can be used in the immediate vicinity of transmission lines where reception with existing medium-frequency amplitude-modulated equipment would be blanked out by noise. An adequate number of channels can be provided.

The first cost of each installation is considerably less than for the medium-frequency equipment now in use. Because of the line-of-sight characteristics of very high frequencies, fixed stations will have to be spaced at closer intervals. Fixed very-high-frequency stations will be interconnected with the microwave system at selected microwave station sites, making use of the existing towers and power facilities.

Power Line Carrier. Power line carrier has been for many years the standard means of long distance communication used by most utilities for operation of their systems. Its application must now be evaluated in competition with the new medium, microwave radio, and in some cases, with very-high-frequency radio. Microwave, with its high first cost and low incremental cost per additional channel, is best adapted to applications where many channels follow the same geographic route. Carrier, on the other hand, with its lower fixed cost and high incremental cost per additional channel, is better adapted to routes or branches where only one or two channels are required. However, in addition to the economic factors, spectrum crowding must be considered. It would probably not be possible, with frequencies available, to provide more than a small proportion of ultimate channel requirements with carrier alone.

Microwave. Microwave has a number of other advantages, including channel reliability, ability to provide many channels on one carrier channel, full duplex communication without crowding of the spectrum, and the ability to be used during construction prior to completion of the connecting transmission line. In addition, multiplex channels encourage use of duplicate equipment and

er means of gaining reliability. This is generally re-
ted in the cost.[1,2]

BONNEVILLE COMMUNICATION PROGRAM

THE MOST important part of the BPA communication program is shown in the map, Figure 2. It will be n that microwave is to assume the burden over the kbone routes where channels are many, and carrier r the branches where the channels are few. Figure 3 ws the microwave and other radio facilities in service planned for the near future.

t is the intent that the existing carrier over the backbone tes will be retained, at least temporarily. If any or of this should be found unnecessary, after the microve proves its reliability, it can be transferred to new nch routes, and the original investment need not be t. Further details of the BPA system can best be dissed in terms of the services provided.

Telephone. Foremost consideration is given to providing cuits for system dispatching. Where possible at small ra cost, telephone circuits will be provided for other ctions, depending upon access to the microwave system d power line carrier and radio extensions. Circuits l be provided as follows:

1. Chief dispatcher to each major generating station—e exclusive channel and one party line.
2. Chief dispatcher to small generating station—two annels, either or both of which may be party line.
3. Chief dispatcher to dispatchers of interconnected lities—one exclusive channel.
4. Chief dispatcher to each subdispatcher—two exclusive channels and one party line.
5. Subdispatcher to attended stations in area—one party line.
6. Maintenance headquarters to district maintenance headquarters—one party line.
7. Administrative offices to district offices and other points—one party line.

Each party line will be limited to six stations or less, depending on volume and importance of traffic.

To provide the telephone service outlined, about 60 telephone circuits will terminate at J. D. Ross at the close of the next 6-year construction period.

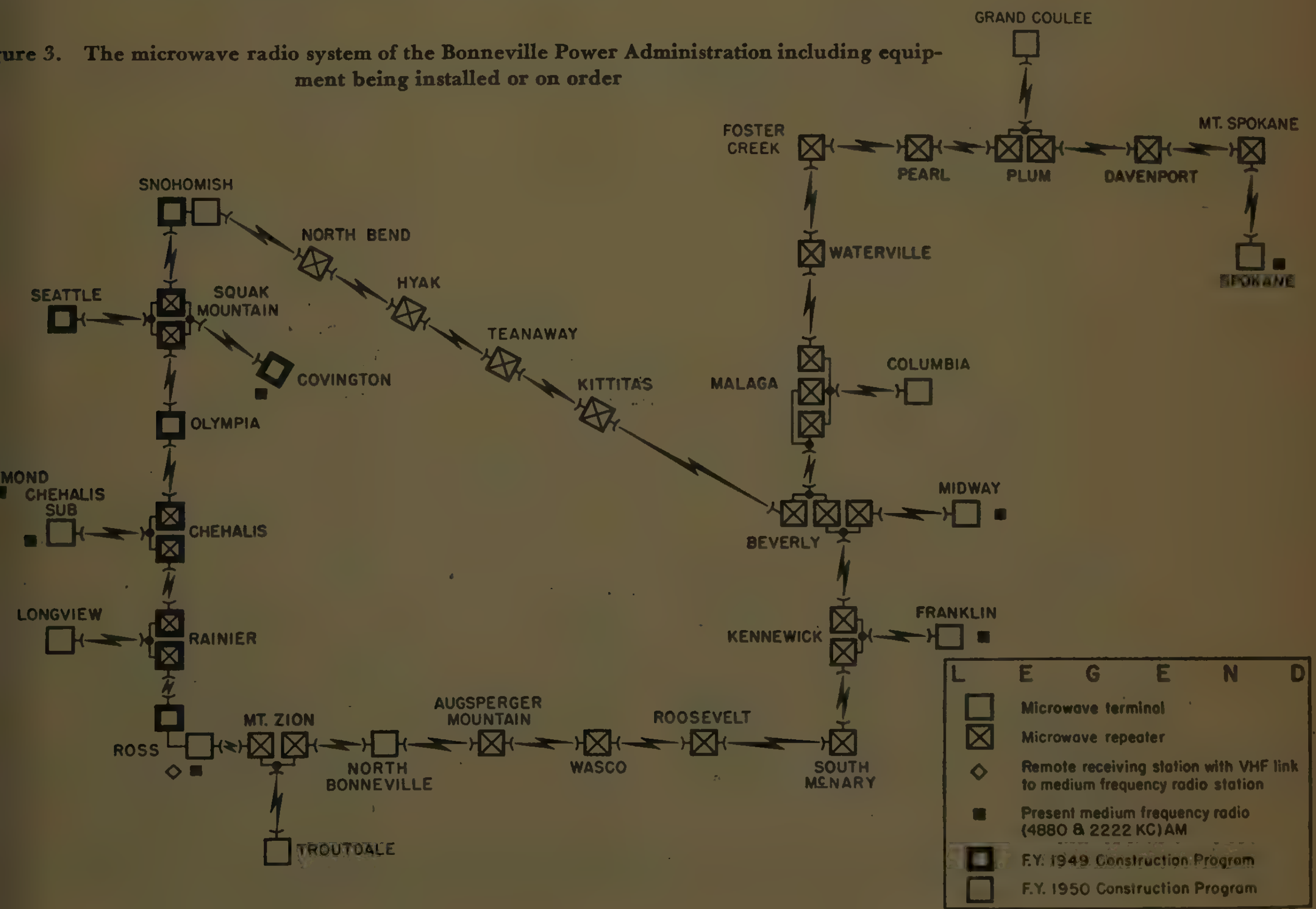
Telemetering—Power. Telemetering is of major importance in providing information for the load dispatcher. As a result, the scheme shown in Figure 4 and Figure 5 has been worked out.

The complexity of the job of operating the network in parallel with those of ten other major utilities is becoming so great that at least three subdispatching points will be required within a few years.

Telemetering equipment now installed provides for bringing information to the load dispatcher on the generation of Grand Coulee and Bonneville. Equipment will soon be added for telemetering of interchange with the other major utilities, with many of whom Bonneville has several interconnections each.

Figure 5 shows the way microwave, carrier, and leased

ure 3. The microwave radio system of the Bonneville Power Administration including equipment being installed or on order



wire are to be combined to provide the most economical channels for power telemetering. At the dispatcher's office, a total of 50 recorders will be required to record power, river flow, voltage, and frequency.

Telemetering—Stream Gauge Readings. In addition to kilowatt telemetering, it is planned to telemeter river flow at four and ultimately six important points on the Columbia River. River elevation will be telemetered to the dispatcher's office, and there will be automatically translated and recorded as second-feet stream flow, in accordance with the calibration curves of the stream beds at the various gauging stations.

The Administration is now co-operating with several other government agencies in developing a comprehensive program for gathering and transmitting stream gauges, precipitation, snow survey, and temperature data. It is planned that this data will be transmitted, probably by teletype, to the offices of the interested agencies in Vancouver, Wash., and Portland, for use in connection with power pool operation, flood control, and irrigation.

Supervisory Control. Conditions on the BPA system are particularly favorable to the use of supervisory control. As a wholesale agency, many of its stations are extremely simple with only one or two secondary circuit breakers. Because such stations are simple, and widely dispersed geographically, and because there is no distribution system to maintain, its operating personnel is normally spread quite thin. Many stations have only one operator, and he obviously cannot be at the station 24 hours a day, seven days a week. Operation in such cases could be made more reliable by supervisory control. Some stations now unattended offer the chance of improved service at reasonable cost with supervisory control.

Power Line Relaying. Microwave has a major fundamental advantage over power line carrier as a channel for relaying, because it is not necessary to assume that the channel may be out of service when the power line is faulted. This permits an approach to the relay problem heretofore impossible, an approach which promises to decrease appreciably the time required to clear certain lines at both ends, and to decrease even more the minimum possible reclosing time. The resulting gain in stable power limit of the transmission system is one of the major advantages to be expected from the use of microwave.

Teletype and Facsimile. Teletype on a toll basis has been used for many years for communication between the Portland main office and the various district offices.

Availability of high-quality channels makes the use of facsimile also seem attractive, as the work of BPA is expected to become more and more decentralized, and there may be considerable need for transmitting maps and sketches between the main office and the various regional and district offices. Also, its ability to transmit large tables of figures without possibility of error is important.

Load Control. Load control channels have not yet been required by the Federal system but may be needed as Federal plants are added. The pool is now commonly operated with Grand Coulee powerhouse controlling frequency and with the connected utilities generally using their automatic tie line load control equipment to regulate their take of power.

Fault Location. Perhaps the most interesting microwave application is to power line fault location. Many investigators in the United States and abroad have been working on this problem in recent years and much progress has been made.[3–5] Engineers of the Bonneville Power Administration have worked on three different systems,[6,7] the most promising of which makes use of microwave links.

This system is designed so that a fault occurring anywhere on the main BPA network will cause its location to be printed instantly, in typed figures, on a paper recorder chart in the load dispatcher's office. Together with the typed distance in miles will be the time in hours, minutes, and seconds.

This is accomplished by the use of a recorder, together with a video

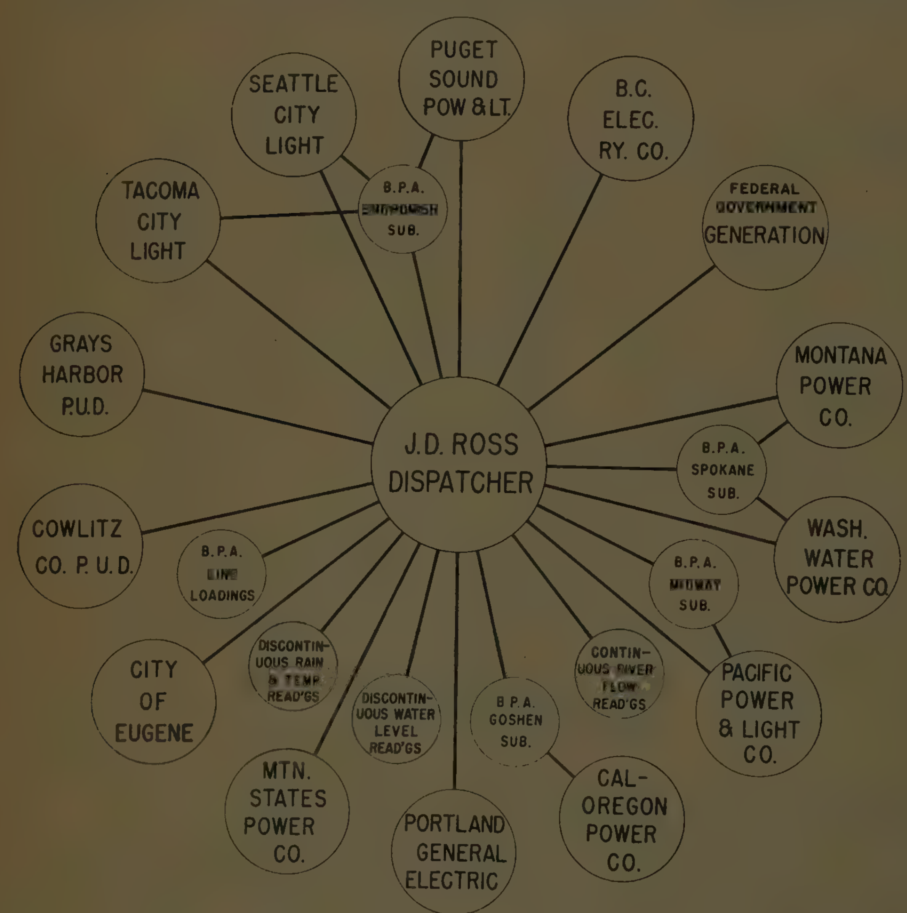
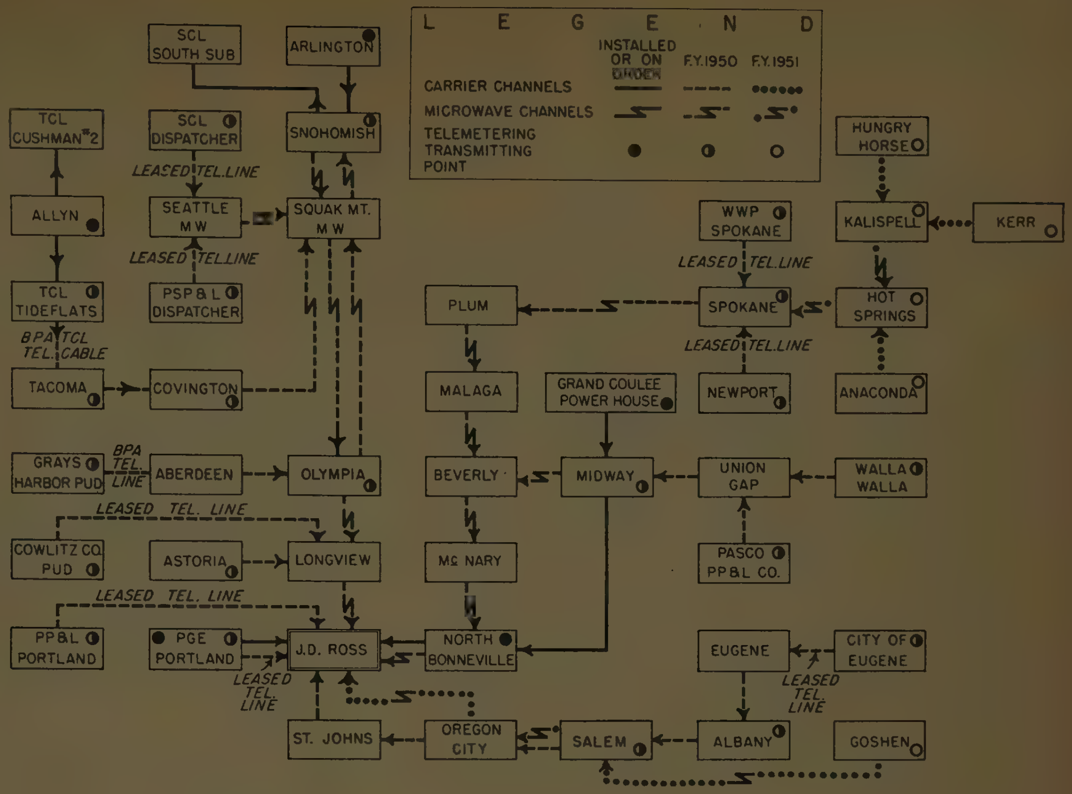
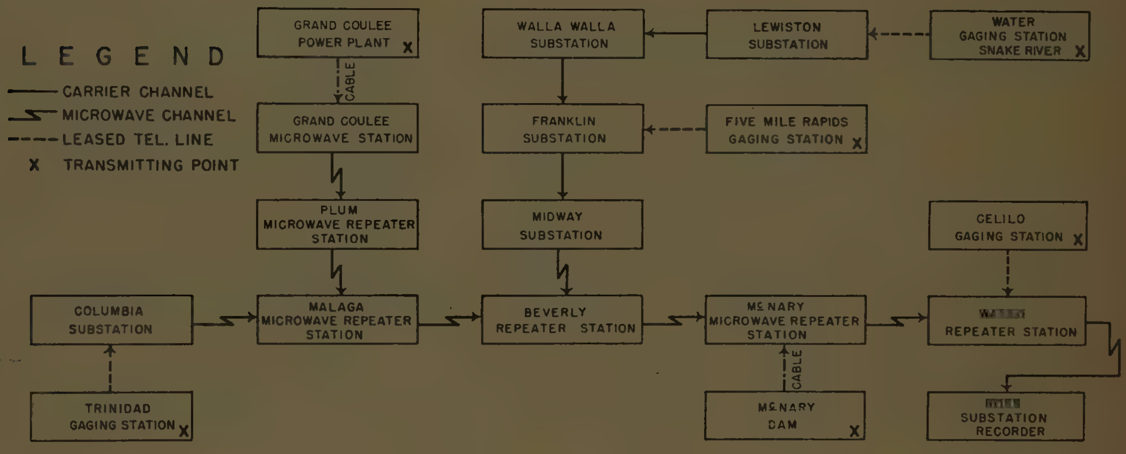


Figure 4. Schematic diagram of the telemetering program of the Bonneville Power Administration



gure 5. Methods of tele-etering generation and terchange power of the stem showing the use of icrowave, carrier, and ased wire channels which e used in the Bonneville telemetering program



gure 6. Schematic the water-flow easuring network of e Bonneville tele-metering system

ming pulse transmitted over the microwave system. The time required to make the measurement is small deed, though ample for the electronic methods used. nce 95 per cent of all faults are of the transient type ot re-established when the circuit breakers are reclosed, nd since it is desired to locate such faults as well as per-anent faults, a measurement must be taken before the c is extinguished. Since relay time may be less than a rcle (of the 60-cycle wave) and the circuit breaker will perate in less than three cycles, the equipment should capable of operating in three cycles, or 50,000 micro-conds. Actually, the measurement of distance is set up n an electronic counter within a few thousand micro-conds.

The setting up of the type wheels to correspond to the ounter reading, being a mechanical operation, takes about ree seconds. Should another fault occur while the type heels are being set up and are printing, the counter will ceive and "remember" the second reading until the first reading is printed, after which the type wheels will be set to the new value which will be printed in turn on the chart.

Data on the location of the fault are thus available at the dispatcher's office in a form immediately usable within three seconds after it occurs.

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Symmetrical Short Circuits on Saturated Alternators

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IN ORDER to solve the problem of a 3-phase short circuit on the terminals of a saturated machine, one generally starts by writing the differential equation for each winding either on the stator or on the rotor. Any of these differential equations is of the form $\epsilon = p\psi - ir$. The solution of these equations under the specified initial conditions gives the solution to the problem. However, the difficulty in their solution arises from their nonlinearity. Here there are two kinds of nonlinearity. The first is due to the change of the coupling coefficients between the different windings due to the rotation of the rotor. This nonlinearity could be removed by using the transform to direct and quadrature components as used by R. H. Park.[1] The second kind of nonlinearity is due to the saturation in the magnetic circuit, and it could be dealt with by separating the solution into a free transient that meets linear conditions and a particular solution that meets saturated conditions and could be obtained using Reinhold Rüdenberg's method by analysis[2] with the initial current being obtained by the principle of conservation of flux linkage.[3] The differential equations of the stator winding transformed to direct and quadrature components as given by Mr. Park[1] are

$$e_d = p\psi_d - \psi_q - ri_d \tag{1}$$

$$e_q = p\psi_q + \psi_d - ri_q \tag{2}$$

Putting $e_d = 0 = e_q$, the conditions for a terminal short circuit, the free transient could be obtained by omitting the

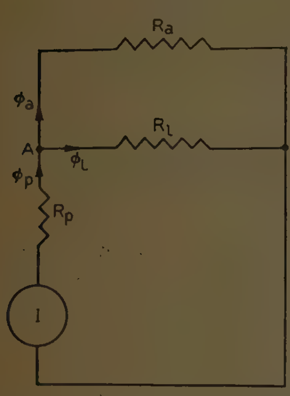

Figure 1. The main magnetic circuit of the machine at no load

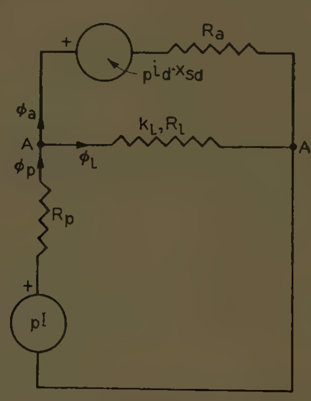

Figure 2. Main magnetic circuit of the machine after short circuit

exciter voltage. In this case the linkages and the currents would be related by the equations: $\psi_d = -{}_f i_d x_{ds}'$ and $\psi_q = -{}_f i_q x_{qs}'$. Making these substitutions in equations 1 and 2, the following differential equations are obtained:

$$0 = -(px_{ds}' + r)\,{}_f i_d + x_{qs}\,{}_f i_q \tag{3}$$

$$0 = x_{ds}'\,{}_f i_d + (px_{qs}' + r)\,{}_f i_q \tag{4}$$

Assuming a small armature resistance and considering that the steady-state current is a direct-axis current, the solution of the foregoing simultaneous equations becomes

$${}_f i_d = -\frac{e}{X_{ds}'}\epsilon^{-t/T_{as}} \cos t \tag{5}$$

$${}_f i_q = \frac{e}{X_{ds}'}\frac{x_{ds}'}{x_{qs}'}\epsilon^{-t/T_{as}} \sin t \tag{6}$$

where x_{ds}' is the saturated direct-axis transient reactance offered to the free transient and is equal to the sum of the stator leakage reactance and the saturated effective rotor leakage reactance. Thus, if the saturation factor of the rotor leakage paths is k_1

$$x_{ds}' = x_s + \frac{1}{k_1}x_r' \tag{7}$$

The free solution of the phase currents could be obtained by substituting equations 5 and 6 in equations 14 of Mr. Park's paper.[1]

X_{ds}' is the saturated direct-axis transient reactance offered to the particular solution of the current and will be evaluated according to the principle of conservation of flux linkage[3] as follows:

Referring to Figure 1, the pole flux at no-load is given as

$$\phi_p = e(1 + R_a/R_1) \tag{8}$$

Referring to Figure 2, and realizing that the left subscript p indicated particular solution, the pole flux after the short circuit is given as

$${}_p\phi_p = {}_p i_d\left(x_s + \frac{x_d}{k_1 R_1}\right) \tag{9}$$

Equating equations 8 and 9 and putting $R_1 = x_{sd}/x_r$

$$X_{ds}' = \frac{e}{{}_p i_d} = x_s\frac{1 + (1/k_1)(x_r/x_{sd})}{1 + \dfrac{x_r}{x_{sd}}R_a} + x_r'\frac{1}{k_1}\left(\frac{1 + x_r/x_{sd}}{1 + \dfrac{x_r}{x_{sd}}R_a}\right) \tag{10}$$

The particular solution is obtained according to Mr. Rüdenberg's method of analysis[2] modified to include the saturation of the pole tips. The solution was checked experimentally on a 100-horsepower synchronous machine; calculated and test results agree within 4 per cent.

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Measuring the Thickness of Thin Coatings With Radiation Backscattering

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The backscattering of radiation from radioactive substances now is being used to measure thin coatings. This is a nondestructive process which can be used in production wherever measurement is to be made of a coating which has a different atomic number from the backing material.

DURING THE PAST two years considerable work has been done in evelopment of beta gauges for ne measurement of the thickess of thin films. In the beta nickness gauge the portion of eta particles absorbed by the naterial has a direct relationnip to the thickness of the material, assuming, of course, that ne material is homogeneous in regard to specific gravity. 'he beta gauge in effect measures mass per unit weight and annot identify different materials of the same specific gravy. For example, water content cannot be measured if the naterial has itself a specific gravity approximating unity.

A second limitation of the beta gauges is the necessity or placing the radioactive source and the detecting head on pposite sides of the homogeneous material to be measured. 'hus, the measurement of thin coatings, such as paint, n plate, and insulation materials, after they are applied a base material, is not possible with the conventional eta gauge. The thickness of such coatings can, nevertheess, be measured nondestructively by the backscatter of adiation if the atomic number of the coating is different om the material to which the coating is applied. The etecting head and radioactive source, separated by a iitable radiation shield, are mounted on the side on 'hich the coating is being applied. Similarly, the thickess of sheets or films can be measured and controlled on alendering rolls.

Some types of materials which can be measured by ackscattering methods which cannot be measured by onventional radiation absorption methods are:

1. Tin or zinc coating on steel.
2. Paint or lacquer on metallic surfaces.
3. Rubber and plastic sheets or film on calendering olls.
4. Selenium on aluminum or other backing materials.
5. Barium coating on photographic paper.
6. Chromium or brass on steel.
7. Fillers in paper and plastics.
8. Porcelain coatings.
9. Metal platings, such as nickel or chromium, supernposed on other metallic surfaces.
10. Plastic coatings on wire.

The amount of rubber or plastic spread on a calender roll just prior to its application to a textile backing, for example, can be both measured and controlled automatically. The sensitivity of this gauge is extremely high for thin films. For example, in a production line test it was found to be capable of measuring extremely thin coatings of tin plate to an accuracy of a millionth of an inch even though there were substantial variations in the steel sheet on which the tin was plated.

The essential components of this gauge are, as in the case of the other beta gauges, a source of beta radiation and a radiation detector. However, the source is located in the same instrument head as the ionization chamber but it is shielded in such a way that radiation emitted from it cannot directly reach the detector. When a layer of the material under investigation is placed in or passed through the measuring position, the ionization chamber is actuated by beta rays diffusely reflected from the material and the resulting chamber current determines the reading of the panel meter. Figure 1 illustrates this arrangement.

The ability of a material to backscatter beta rays in this way is a function of its atomic number. Increasing the thickness of the material produces lessening increments in detector response until a final value of chamber current is reached unaffected by additional increases in the thickness of the material. Figure 2 depicts a typical characteristic curve obtained in this manner. The final value of detector current is obtained when the maximum beta ray energies can no longer penetrate to the farthest edge of the material and still have sufficient energy left to return, by scattering, to the chamber. The thickness at which this saturation occurs is frequently referred to as the infinite thickness and depends upon the maximum beta ray energy emitted by the source. The final value of chamber current is a function of the scattering properties of the material being measured.

If a layer of another material of different atomic number is superimposed upon the scattering surface of the first

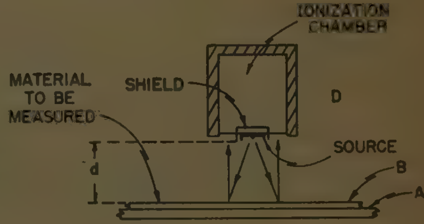

Figure 1. Source and chamber mounting for measurement of the thickness of material B by backscattering of beta particles

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material, the chamber response decreases or increases respectively as the change is to lower or higher atomic number. Figure 2 illustrates a positive increase, indicating a change to a higher atomic number. The chamber current continues to increase with additional thicknesses of the superimposed material until again a final value is reached depending on the atomic number of the coating.

In order to obtain useful measurements of the variation in weight per unit area of the superimposed material it is necessary that, for the particular source being used, the thickness of the coated material be infinite so that variations in its weight per unit area do not affect the readings, while the range of the thickness of the coating be such that it lies in the initial, approximately linear, region of the characteristic curve. This naturally sets the requirements for the type of source that is to be used in any given application, since the penetration of beta radiation is different for different radioisotopes. Furthermore, the two materials must be sufficiently far apart in atomic number to give distinctly different infinite-thickness chamber currents.

The backscattering-type beta gauge is normally supplied with a time constant of several seconds to minimize fluctuations in the meter. In most instances, on production line measurements, it is desired to obtain variations in average thickness of a sheet rather than point-to-point variations. Experience has indicated that this damping effect is desirable, since it provides a reading which is much more easily interpreted than a rapidly fluctuating reading. The need for changing machine settings shows up very quickly, since a distinct trend is indicated almost instantaneously, even though it may take several seconds for the indicator to reach equilibrium.

Operationally, a source mount S containing a beta-emitting radioisotope is located outside the window of a radiation detector D, Figure 1. The window face is thinner in structure than the other sections of the detector to permit the entrance of beta particles from this direction. Normally radiation from the source mount is propagated outward, and no response is observed in the detector.

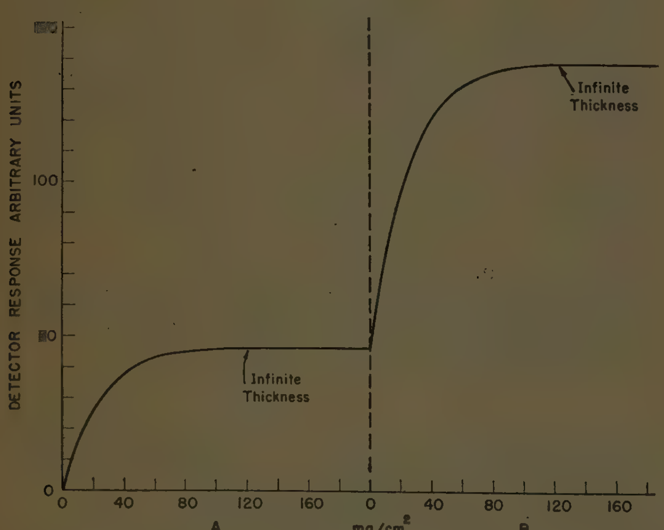

Figure 2. Backscattering absorption curve for two types of material, each absorber of higher atomic number than the backing material

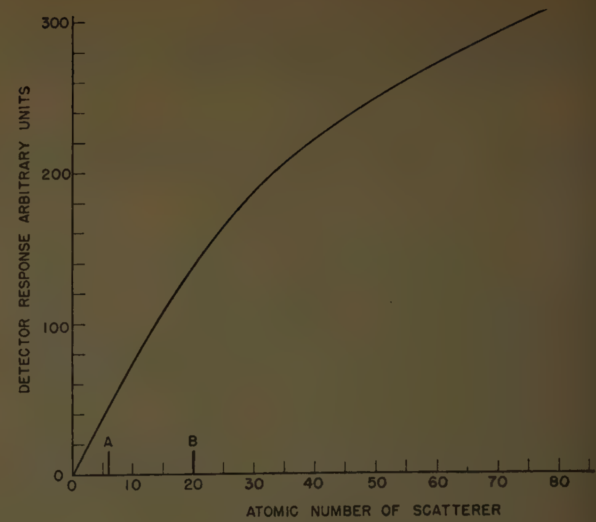

Figure 3. Backscattered current as a function of the atomic number of a scatterer of infinite thickness

If a layer of material A is now inserted into measuring position beneath the source and detector, some beta particles will be scattered or diffusely reflected by A and return to enter and energize the detector. As the weight per area or thickness of A now is increased, more and more beta particles which had previously penetrated beyond A suffer path deviations while in the reflecting medium and return to cause increases in detector response. This effect, plotted as the curve in Figure 2, reaches a final asymptotic saturation value when A becomes so thick that the most energetic beta particle no longer can penetrate to the furthermost edge of A and still possess sufficient energy if backscattered at that point to return through this same thickness to enter and actuate the detector. The value of weight per area (milligrams per square centimeter) at which the saturation value of detector response is attained depends only upon the maximum beta particle energy emitted by the source. This thickness is termed the infinite thickness of the material for the particular beta-emitting isotope. The value of detector response attained at this thickness is a function of the atomic number of the scatterer.

The scattering of beta particles is accomplished by two mechanisms: electrostatic interaction between the beta particle and electrons present in the scattering medium and, in addition, nuclear scattering due to the generation of coulomb forces between the beta rays and the positively charged scattering nuclei. Figure 3 depicts the variation of detector response versus atomic number of scatterers of infinite thickness for a particular isotope, Ru^{106}.

Consider now a layer of material B superimposed on A possessing an atomic number different from A. The response in the detector will now increase or decrease depending on whether the change is to a higher or lower, respectively, atomic number. In the case shown in Figure 2 the change is to a higher atomic number and the response in the detector rises with increasing weight per area of material B until a new saturation value of detector current is reached. The saturation value of current depends only upon the atomic number of material B, since

same radioisotope is employed. The infinite thickness value of B in terms of milligrams per square centimeter is the same as it was for A. The two curves in Figure 2A and 2B differ only by a constant ordinate factor. Empirically, the analytical function describing these curves was found to be

$$=1-\epsilon^{\mu w}$$

where $I_{\text{i.t.}}$ represents the response in the detector at infinite thickness; μ, the coefficient of scattering; and w, the weight per area of the scatterer.

A noteworthy fact is that the shape of the curves shown in Figure 2 is independent of the geometry of the source-detector unit with respect to the scatterer. A single ordinate factor is introduced when the plane of the scatterer is changed from being perpendicular to the axis of the source-detector unit to an inclined position, or even curved, such as in the measurement of material flowing over a calendering roll. A simple sensitivity control is provided which can be adjusted to compensate for this factor introduced by changing geometry. Calibration information obtained with only one kind of material serving as scatterer can be applied to all other substances by simply adjusting its detector sensitivity control.

It is essential when measuring one material superimposed on another of different atomic number that the instrument be insensitive to variations in the thickness of the base substance. This means that the minimum thickness of the base material at least equals the infinite thickness for the beta rays employed. If this thickness is slightly less than infinite thickness, only small errors are introduced because of the small slope of the backscattering characteristic in the region of infinite thickness. In other words, the gauge becomes grossly insensitive to variations in the thickness of the base material provided it is in the region of infinite thickness.

One very critical consideration as far as industrial instrumentation is concerned is the sensitivity of the gauge to variations in the distance d, Figure 1, between the source-detector unit and the surface of the scatterer. If d is considered equal to 0, all of the beta particles reflected from the material being measured would be absorbed by

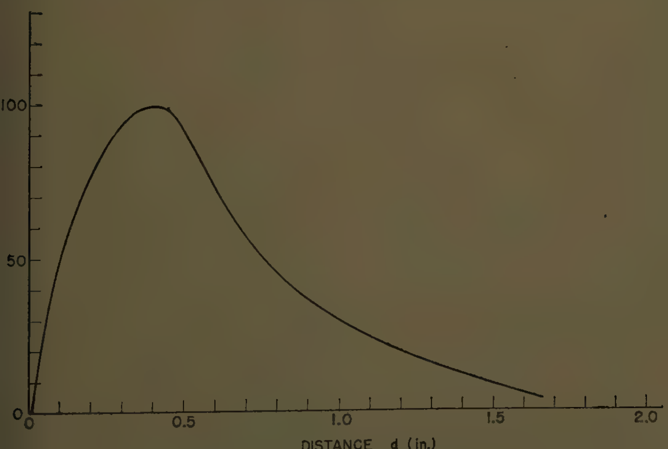

Figure 4. Backscattered current as a function of distance between detector and scatterer

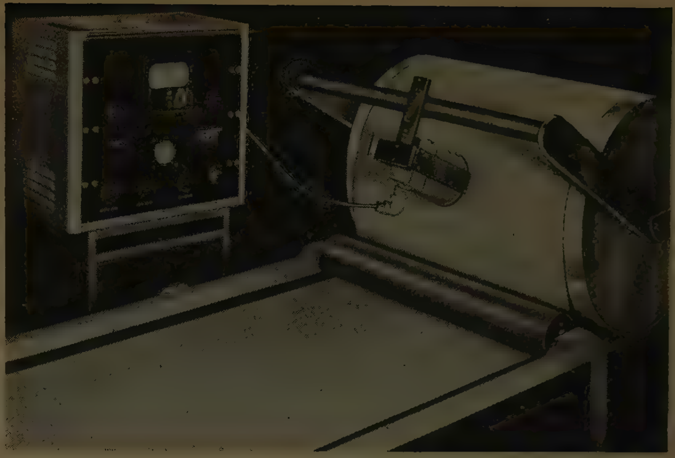

Figure 5. Backscatter beta gauge measuring the thickness of rubber film on demonstration calender roll. This type of measurement enables control of material being formed on the roll

the source mount S while returning to the detector. As d is increased from zero by moving the source-detector unit away from the surface of the scatterer, more and more radiation enters the detector until d becomes so large that the solid angle subtended by the detector at the scattering surface becomes sufficiently small to cause the response in detector to decrease. Figure 4 indicates the variations in detector response with changes in d for the gauge shown in Figures 1 and 5. It is seen that an optimum value of d exists which makes the instrument insensitive to variations in d, in this case 0.40 inch. This optimum value is independent of the nature of the scattering material being measured and almost independent of radioisotope. It is a function of source-detector and scatterer geometry.

Empirically, it has been found that the error of reading that can be achieved in a practical instrument can be expressed as ± 0.3 milligram per square centimeter $\div$ atomic number units, or ± 1 per cent of full-scale meter reading, whichever is greater. For example, if the atomic number difference between the two surfaces is 30 units (tin on steel), then measurements can be made to ± 0.01 milligram per square centimeter (0.3/30). Because of the nonlinearity of all backscattering characteristics, special meter calibrations must be made for instruments in which a large portion of such a characteristic appears on its meter face at one time.

The backscatter beta gauge represents one of the first significant industrial applications of synthetic pile-produced radioisotopes. The backscatter and beta gauges in all of their ramifications have potential uses in industry to perform measurements and controls automatically.

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Improving Surface Condenser Performance

J. G. DOBSON

SLIGHT VARIATIONS in the performance of the surface condenser of a steam turbine power plant can make substantial differences in the over-all thermal efficiency of the plant. Since this portion of the plant has been to date the subject of less intensive study as far as supervisory instrumentation is concerned, the surface condenser has been chosen as the typical unit to be studied from the viewpoint of supervising instruments.

The choice as to whether an instrument should merely provide a record or an alarm to guide the operator or take some positive step to prevent damage depends entirely on how critical the operation of the equipment is, and whether there is some action which the instrument can initiate without having to evaluate more factors than are available in the measurements which are being carried to the instrument.

Figure 1 illustrates typical instrumentation for the surface condenser. Of eight measurements made, three are for the protection of equipment. The differential across the water side of the tubes is measured to determine when plugging of tubes and tube sheets with trash and marine growths occur, and an alarm warns the operator of such a condition. The absolute back pressure is measured to provide a warning of excess pressure and temperature likely to damage the condenser. If these pressures exceed a preset value, due to water failure or another cause, automatic shutdown of the turbine is provided to protect equipment. Measurement of the conductivity of the condensate being pumped from the hot well permits automatic diversion of contaminated condensate in the case of condenser leakage.

The remaining five of the eight measurements are used to evaluate and control the over-all operating efficiency of the condenser. Two of the major factors affecting such efficiency are the partial pressure of air within the condenser and the rate of heat transfer. Air partial pressure may be measured directly using the Foxboro differential vapor pressure cell which measures the difference in pressure between the water vapor at the temperature of saturated steam within the condenser and actual pressure within the condenser. The difference between these two measurements is the partial pressure of gases which are in the condenser shell.

Measurement of undercooling of the condensate in the condenser is obtained by measuring the temperature difference between the saturated steam at the turbine outlet and the temperature of water in the hot well. Control of circulating water rates is best effected by the use of the auto-selector controller, which controls the water circulating rate based on the measurement of absolute pressure in the condenser and of undercooling of the condensate. This controller automatically shifts control from one measurement to the other to maintain a minimum undercooling consistent with maintenance of required absolute pressure.

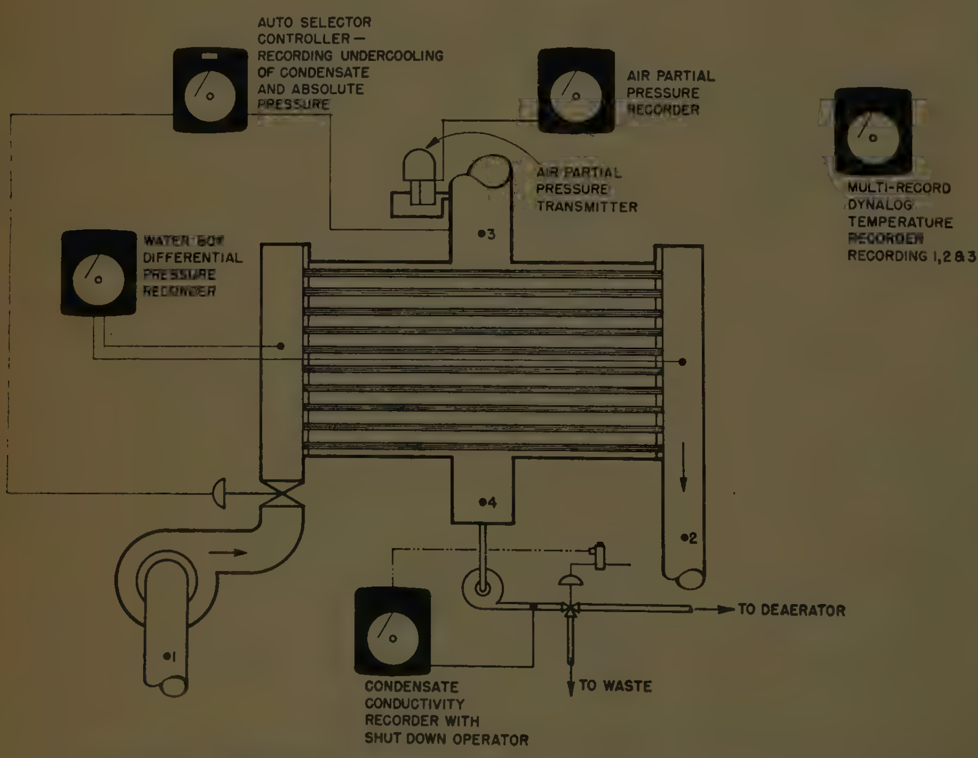

Figure 1. Proposed supervisory instruments for steam surface condenser

It is hoped that this outline of supervisory instruments on condenser operation will indicate the precision of plant operation which instruments now readily available can aid in achieving. Actually, all instruments covered in this discussion have been in commercial use for at least a year and are well proved. The combination of these with other well-known instruments will effect a savings in manpower as well as maintain the continuity of operations so necessary to the highly integrated modern power house.

Digest of paper 50-265, "Improving Surface Condenser Performance Through the Use of Supervisory Instruments," recommended by the AIEE Committee on Power Generation and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Oklahoma City, Okla., October 23-27, 1950. Not scheduled for publication in AIEE *Transactions*.

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Air Delayed Selective Overcurrent Tripping Device

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CONOMICS of modern power distribution demand more than ever before that service on low-voltage ems be continuous and that unfaulted portions of the em receive a minimum of interference as a result of ts elsewhere on the system.

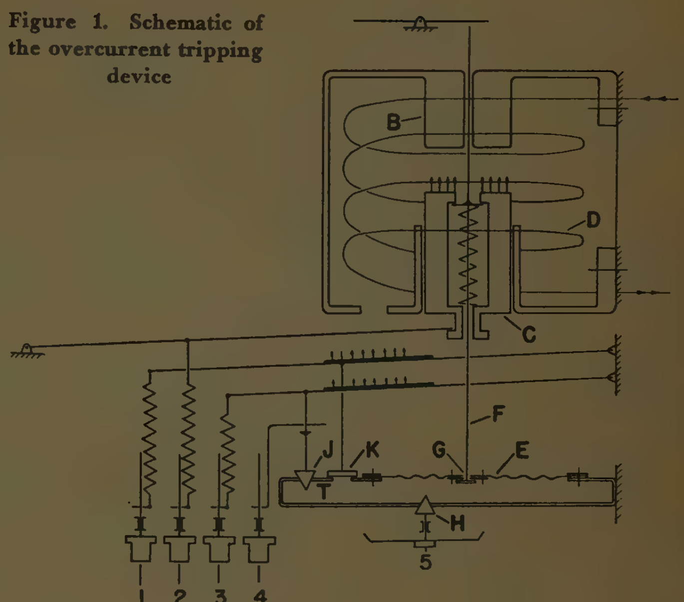
his requirement has popularized the use of a selective ping arrangement which, in turn, has imposed new uirements on both air circuit breakers and the tripping ices used with them. Because of the simplicity afforded direct-acting series tripping devices, attention has been ised on this type of device and its time-current charac-tics.

he time-current requirement of a tripping device es considerably with the position of the circuit breaker selective system and, therefore, a device providing a e range of adjustment is essential for general applica-. To achieve the main objective, the device must ction repeatedly as an accurate timer under variable perature and atmospheric conditions; it must also ess the all-important feature of resettability which bles the device to respond to an overcurrent impulse to halt tripping action and automatically reset to its ial condition if the overcurrent is removed by some other tective device.

series device has been developed which provides a 1 degree of adjustability together with a delaying nent which is virtually immune to temperature or other ospheric changes. This series overcurrent tripping ice is shown in Figure 1 and with the suitable coil can ised on 225-, 600-, and 1,600-ampere frame size circuit akers.

eferring to the schematic diagram, Figure 1, an over-l or short-circuit current through the series coil *D* will se the moving core *C* to be attracted and move toward stationary core *B*. At low currents, the moving core ill carry the tripping stem *F* along with it, immediately ing valve *G*, after which motion is retarded by the ohragm *E*. The rate of travel of the diaphragm is ermined by the rate at which air is permitted to enter mber *T* by the various valves *H*, *J*, and *K*. At higher ents when the attraction between the moving core *C* the stationary core *B* is greater than the load on the ng inside the moving core, the moving core will com-s the spring and travel independently of the tripping 1 *F*. This spring ensures a constant maximum force ern acting on diaphragm *E*. By limiting, in this way, maximum force transmitted to the delaying element, motion of the tripping plunger is dependent only on

Figure 1. Schematic of the overcurrent tripping device



the rate at which air is admitted to chamber *T* through the long delay, short delay, and instantaneous valves.

The long time element purposely delays tripping of the circuit breaker on motor-starting, overload, and high-impedance fault currents. Knob *2* in Figure 1 permits an adjustment from 80 to 160 per cent of coil rating for the long time delay pickup, and dial *5* controls the long time adjustment from 4 to 90 seconds.

The short time element intentionally delays tripping of the circuit breaker on fault currents. The amount of delay can be adjusted over a range of from 4 to 30 cycles by means of knob *4*. The current at which this delay becomes effective can be adjusted over a range of from 500 to 1,000 per cent of coil rating by means of knob *3*.

The instantaneous element provides no intentional delayed tripping of the circuit breaker, consequently it is the fastest operating element. The magnitude of current at which instantaneous pickup will take place can be varied over a range of from 1,000 to 1,500 per cent of coil rating by means of knob *1*. It has an over-all clearing time of approximately two cycles for currents above the pickup setting.

The time-current curve of this air delayed device will show an inverse time characteristic up to approximately 500 per cent of coil rating in the long time range. Above 500 per cent, the tripping time is constant with increase in current for long time, short time, and instantaneous elements.

This completely adjustable tripping device is particularly suited for selective applications. A system consisting of transformer, sectionalizing feeder, and load circuit breakers can be made selective provided the circuit breakers are equipped with this device.

t of paper **50-271**, "An Air Delayed Selective Overcurrent Tripping Device for Voltage Air Circuit Breakers," recommended by the AIEE Committee on Switch-and approved by the AIEE Technical Program Committee for presentation at the Fall General Meeting, Oklahoma City, Okla., October 23–7, 1950. Scheduled iblication in AIEE *Transactions*, volume 69, 1950.

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Transformer Oil

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THE HIGHLY COMPLEX NATURE of the material, the resulting difficulty in establishing significant tests for evaluation in a reasonable time, and the varying conditions of use have combined to make the study of oils used for the insulation and cooling of transformers a painfully slow process. It is the purpose of this article to review some of the very extensive efforts made in this study and to draw at least tentative conclusions as to the present status and future possibilities of one of the most important materials in the design, manufacture, and operation of transformers.

During more than 50 years of use of oil as an insulating and cooling medium in transformers, great effort has been devoted by refiners, apparatus manufacturers, and operators to testing procedures by which oils for this purpose could be evaluated, and the matter has been and is being continuously studied by the American Society for Testing Materials and other national and international bodies interested in the subject. Various procedures have been proposed, but there is no unanimity as to the value of these procedures for predicting the performance during life of an oil from its initially measurable properties or as to the parallel problem of determining the further usefulness of an oil which has been in service.

In an effort to obtain more definite information than can be procured in the field where load conditions are uncontrolled and where it is difficult to obtain good records, a number of small transformers have been operated for periods up to 15 years under controlled conditions and with oil samples available for laboratory measurements. Data have been taken from 30 transformers whose structures were representative of distribution-transformer practice; that is, without tight sealing. In these transformers, comparisons were made between oils with and without inhibitors, and between transformers using varied impregnations.

Data, particularly on the oil acidity and sludge formed during operation, are recorded and by choosing certain acidity levels and quantities of sludge formed, an arbitrary decision as to the end of useful life is reached. It is concluded that the type of impregnant used has an important bearing on the life of the oil, but absolute ideas of the life of oil are not given because of the many factors involved. The data generally support previously formed ideas as to the effect of temperature change on life; that is, the degradation is more or less continuous with normal oils, and it is halved or doubled by an increase or decrease in temperature changes of from seven to ten degrees. It is evident that overloading of transformers would tend to decrease the life of the solid insulations more rapidly than that of the oil.

Since the aging of oil is in large part a process of oxidation, the various schemes for minimizing or eliminating oxygen from the oil will have a very important effect in increasing the life of oil in such transformer structures.

Among the transformers were a number in which inhibitors had been added to the oils either for the purpose of determining their effect in extending the life of normal oils or in the effort to make less well-refined oils give life of the same order as good normal oils. No conclusive results were obtained, but it is evident from the long life of normal oils in transformers from which oxygen is excluded that the use of inhibitors must be questioned at least from an economic standpoint.

While some presently available inhibitors have properties which would justify careful study from the standpoint of economics, other complexities will be unavoidably introduced. If there were available today one or more inhibitors which were considered to be completely satisfactory, the decision to use them in oil for new apparatus still would be largely influenced by practical considerations for which present knowledge is limited. Such things as the suitability of such oils for circuit breakers and bushings, the compatibility of various inhibited oils, their limitation to a practical number, and the eventual problem of reclamation and disposal of inhibited oils must be considered. New inhibitors and inhibited oils are being made available and additional ones may be developed. The data indicate that careful consideration must be given not only to the inhibitor but to the base oil as well. It will take much time to evaluate these oils and inhibitors and to arrive at conclusions as to their merits. There is no doubt that the life of oil can be extended by the use of inhibitors, but the problem is to evaluate the over-all economic, dielectric, chemical, and practical advantages and hazards presented by such oils in commercial service.

While the data seem to establish a fairly long life even for semisealed units, many operators accumulate a supply of used oils which would be useful in old apparatus if simple reclamation processes were available. Much recent work along these lines indicates the feasibility of treating such oils to a suitable degree with Fuller's earth and then adding an inhibitor.

In summary, the life of oil in transformers is substantially influenced by the materials in the transformer, and oil which has well chosen materials and suitable means for excluding oxygen is comparable to the life of solid insulating materials. Use of inhibitors in reclamation processes for badly oxidized oil may be of value. Probable cost of the whole process is in the range of 8 to 15 cents per gallon and will indicate to what extent these processes will show economy.

Digest of paper 50-165, "Transformer Oil," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer and Pacific General Meeting, Pasadena, Calif., June 12–16, 1950. Scheduled for publication in AIEE *Transactions*, volume 69, 1950.

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The Need for Equipment to Test Aircraft Electric Motors

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This is a discussion of one manufacturer's program to provide a test facility for evaluating rotating electric equipment not exceeding 100 pounds in weight and over-all dimensions of 30 by 10 by 15 inches, and having d-c or a-c power dissipation of five kw. The program required two years to complete at an expenditure of more than $160,000.

LERT manufacturers of electric devices for aircraft must continually analyze their ability to conceive, evaluate, and produce in adequate quantities new equip-it to meet the ever changing performance needs of civil military aviation. This statement is especially true of npanies which may feel the major manufacturing impact various X-group Air Force programs authorized by ngress.

n important segment of the large problem is the matter equipment performance luation. In recent months phase of designing for craft has been rendered reasingly difficult both by complexity of current ironmental requirements l tests and by continued ult upon the limits of operating arena. Test ipment, painstakingly and eniously designed to ulate specified operating conditions, often may become olete in the time consumed by the drafting, development, curement, and installation cycle.

nalysis of one manufacturer's problem revealed that ipment was needed to meet existing specifications of eleration, altitude, low temperature, mechanical shock, l vibration. In some cases, equipment already available s obsolete because it failed to meet revised requirements. other instances it was of inadequate physical or thermal acity. Engineers were assigned the responsibility of aining, either by purchase or by manufacture, a group indicative testing machines. The project was sub-ided into the following phases:

. Analysis of currently applicable military specifica-ns to establish immediate testing goals.

. Selection, through discussion with official aero-tical groups, of goals sufficiently beyond existing re-rements to insure utility of the equipment when actually into service.

. Examination of appropriate equipment both inside l outside the company, on the premises of other industrial anizations, or among the laboratories of the Armed ces.

. Choice between purchasing or building the desired chines.

text of paper **50-277**, "Aircraft Electric Motors Need Test Equipment," recom-led by the AIEE Committee on Air Transportation and approved by the AIEE nical Program Committee for presentation at the AIEE Middle Eastern District ing, Baltimore, Md., October 3–5, 1950. Scheduled for publication in AIEE *actions*, volume 69, 1950.

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Discussion of the program as it was applied to the several pieces of equipment will follow this outline.

ACCELERATION

IN SPECIFICATIONS *AN-M-40*[7] and *AN-I-10b*[5] are found requirements for acceleration tests on two types of rotating equipment, d-c motors and inverters. Motors must "start and run satisfactorily" while "mounted on a centrifuge operated at a speed that will produce an acceleration of ten gravitational units (g's)." The test is made for six positions of the motor. Inverters are required to withstand the force, in each of six axial directions, of five g's. Under this test, a maximum deviation of three per cent in controlled voltage and frequency is allowed at full load and at no load. An earlier specification, *USAF-32590*,[1] requires a test of 12 g's.

The United States Air Force (USAF) General Specification for Environmental Test of Equipment *41065-B*[2] stipulates that test equipment must be capable of administering steady accelerations up to 20 g's.

It is significant that acceleration requirements are not encountered in all specifications. The indication is that the test is not of universal importance. Investigation of this point with representatives of one of the Services, however, revealed an opinion that acceleration performance to them is more important than operation through short-duration shocks. At the recommendation of this group, a design "bogey" of 100 g's was established for a new centrifuge.

No equipment suitable for the testing of rotating machines was discovered within the company or within the laboratories at Wright Field, Ohio, or the Naval Research Laboratory, Anacostia, Md. Accordingly, it was necessary to develop a new device.

Centrifuge Design. The new centrifuge (Figure 1) is designed to carry a load of 400 pounds distributed in the following way:

Test piece	100 pounds
Mounting	100 pounds
*Counterbalance	200 pounds

* May be a second test piece and mounting.

Maximum acceleration of 103 g's is obtained at 450 rpm and a radius of 18 inches. The centrifuge is a 4-foot-

Figure 1. A 100-g centrifuge designed to carry a load of 400 pounds

diameter steel table out of which rises a 12-inch square shaft. Provision is made for mounting test pieces on the flange and on the sides of the shaft, if desired.

The drive is a 15-horsepower d-c motor utilizing automatic speed control. Interlocks are provided to prevent accidental operation of the machine when test motors are being assembled or removed. The control circuits can be arranged for dynamic braking or plugging to obtain rapid stopping. Preliminary tests indicate that the plugging circuit will not be necessary. The motor will bring the fully loaded centrifuge up to 450 rpm in approximately ten seconds.

Power to operate the units under test is provided through 14 slip rings located at the top of the machine. That number is considered adequate not only for power but for instrument or thermocouple leads as well.

The entire machine is surrounded by a shell of $^3/_4$-inch steel plate to protect operating personnel in case of a failure of mounting or motor.

ALTITUDE AND LOW TEMPERATURE

Applicable Air Force-Navy specifications in effect at the opening of this program require operation up to 50,000 feet, at a temperature of −55 degrees centigrade. The generally accepted temperature-altitude combination is as shown in Figure 2, taken directly from specification *AN-M-40.*[7]

USAF Specification *41065B*[2] suggests that apparatus for altitude testing should be capable of holding 85,000 feet and an internal ambient temperature of −65 degrees centigrade. It further requires that the dew point of internal air be controllable between zero and −80 degrees centigrade. A warning is added that no grease, oil, or other impurities shall be present within the evacuated space. Another reference to quality of the air is found in an earlier specification, *AN-M-10a,*[6] where a dew point o[f] −50 to −80 degrees centigrade is specified.

The careful design and construction of a good altitud[e] chamber can take 12 to 18 months. In these days, wit[h] ceilings continually rising and unexpectedly low tempera[-]tures being recorded, it is difficult to decide what per[-]formance will be needed two years hence. Altitudes o[f] 60,000 and 80,000 feet are already being specified. Hori[-]zons of 200,000 feet are mentioned for sustained flight[.] Temperatures of −85 degrees centigrade in conjunctio[n] with high altitude are being reported.

Furthermore, the difficulty of design and the cost in tim[e] and money of chamber construction increase cumulativel[y] as altitudes become higher and colder. Even at altitude[s] under 100,000 feet, heat dissipation by convection is prac[-]tically nil, and refrigerating plate areas increase by leap[s] and bounds. At the same time, the lower temperatur[e] levels tax the capabilities of simple refrigerating system[s] using normal refrigerants.

Under these circumstances the problem of setting prac[-]ticable design parameters was a difficult one.

Figure 3 shows the predicted performance of the chambe[r] which became the final design after most of the elements o[f] compromise had been considered. For light thermal loads[,] an ambient temperature of −45 degrees centigrade wil[l] be available at 100,000 feet. The chamber was designe[d] to dissipate 3 kw plus internal fan and lighting losses a[t] −65 degrees centigrade and 60,000 feet. Minimum col[d]

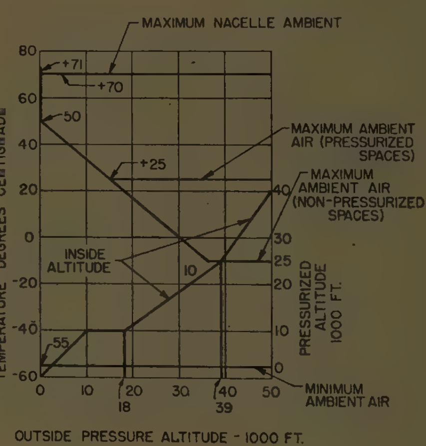


Figure 2. Standar[d] temperature - alti[-]tude chart take[n] from reference 7

temperature at low altitudes of −75 degrees centigrade i[s] predicted.

Investigation of numerous altitude chambers throughou[t] the eastern part of the country revealed none which wa[s] completely suitable. A 90,000-foot chamber at Wrigh[t] Field had no refrigeration. An 80,000-foot chamber i[n] the Lynn River Works of the General Electric Compan[y] was too large, having been designed for engine testing[.] Another 80,000-foot tank at Wright Field was withou[t] humidity control. The chamber most closely resemblin[g] the needs of the program was located in the Naval Re[-]search Laboratory. Rated at 70,000 feet, −60 degree[s] centigrade, and equipped for admitting clean dry air, i[t] included humidity control down to −60 degrees centigrad[e] dew point.

It was decided to design a new chamber. The part

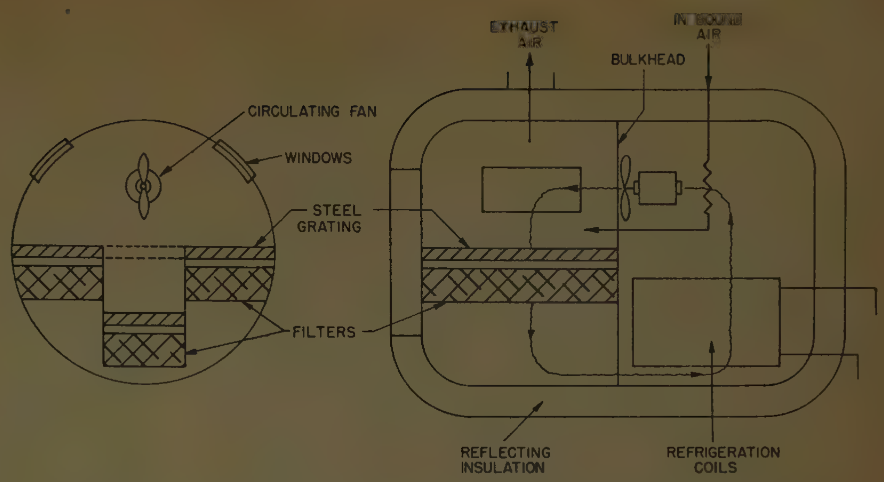


Figure 4. Front and side projections of the layout of the altitude chamber

vould be purchased wherever ap-
roved components could be found, nd the entire chamber and auxili-ry devices would be assembled on he manufacturer's premises.

Mechanical Design. The structural ackbone of the chamber is a 10-oot-diameter reinforced steel hori-ontal cylinder $^3/_8$-inch thick and bout 15 feet long. Centrally fixed vithin this piece is a second cylinder nade of stainless steel and having an nside diameter of eight feet and ength of $13^1/_2$ feet (Figure 4). The even feet to the rear of this space, eparated by a bulkhead, enclose ooling coils and internal circu-ating fan. The remainder is ar-anged to provide 50 square feet of work space. A ectangular door 74 inches by 30 inches, mounted on the ront end of the tank, provides physical access to the nterior.

The space between the two cylinders contains reflector-ype insulation of stainless steel. There are 17 layers of).005-inch sheets located on $^1/_2$-inch centers provided with reather holes between layers to permit evacuation of the ntire assembly without distortion of the insulation struc-ure. A window is provided on each side of the chamber nabling operators to observe tests in progress.

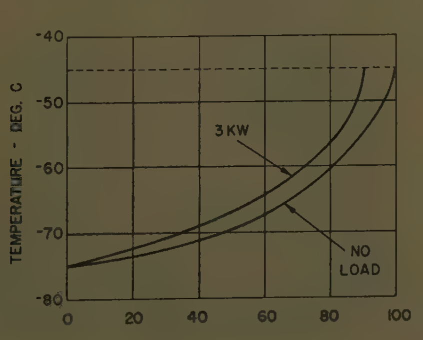
It is an almost universally accepted fact that the keynote n reliable altitude chamber performance is cleanliness and dryness of the ambient air. This characteristic of chamber peration reflects itself in design in at least five points.

1. The interior must be free from materials which retain noisture vapor or other contaminants. Finishes or ma-erials having a vapor pressure of their own must be voided.
2. The evacuation and through ventilation system must andle only dry clean air.
3. There must be provision for purging the chamber vith quantities of dry clean air at the beginning of tests.
4. Interior ventilating and refrigerating systems must emove dust and vapor contaminants from circulating air.
5. Leakage of all kinds must be kept to an absolute ninimum.

Vacuum System Design. Evacuation of the new chamber s accomplished by a 750-cubic-feet-per-minute vacuum pump driven by a 40-horsepower motor. Specified pull-down time to an interior pressure of eight millimeters of mercury (100,000-foot altitude) is six minutes. An altitude condition of 60,000 feet can be obtained in three minutes. Bleed-in air is taken from the factory compressed-air line at 25 degrees centigrade, 90 pounds per square inch (Figure 5). It is passed through filters and refrigerated to +5 degrees centigrade to remove contamination and much of the moisture vapor. An activated alumina drier removes most of the remaining water vapor and delivers approximately 90-pounds-per-square-inch air having a dew point of −80 degrees centigrade and a temperature of +10 degrees centigrade to an expansion valve located just outside the chamber. At this point provision is made for sampling the air and measuring the dew point. The cooled, cleaned air is allowed to expand through a second cooling coil, located in the internal refrigerated circulating air stream, into the front section of the chamber. A flexible tube is provided so that incoming air can be directed to any desired spot within the work area.

At sea level pressures, 300 cubic feet of prepared air per minute can be drawn in and circulated through the tank for purging purposes. This value represents about one complete air change every two minutes in the inner tank. At an altitude of 60,000 feet the vacuum-pump capacity of 750 cubic feet per minute will draw about 75 cubic feet of purified sea level air into the chamber each minute. At 100,000 feet the per-minute bleed-in volume is nearly 10 cubic feet of atmospheric air. Both of these conditions represent a complete air change every minute within the tank.

The suction pipe to the vacuum pump draws air directly from the work space. Like the bleed-in line, the exhaust can be fitted with a flexible tube if it is desired to withdraw air from any specific portion of the test area. The low-pressure air is filtered before reaching the pump to prevent damage to that component from excessive contamination and carbon dust. Automatic altitude control is provided by means of by-passing clean air from the outlet of the alumina drier (or the high-pressure filter) to the inlet of the continuously running vacuum pump. The device controlling this operation also records internal pressure.



igure 3. Predicted erformance of the altitude chamber

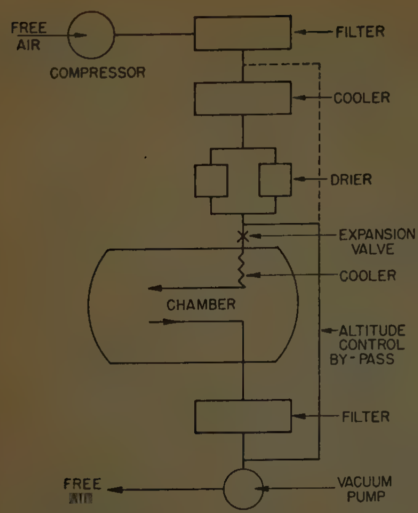


Figure 5. Altitude chamber ventilation system including preparation of the in-bled air

Refrigeration Design. Low temperatures inside the chamber are developed by a 2-stage mechanical refrigeration system using Freon-22 gas. Three 40-horsepower 1,750-rpm motors drive 8-cylinder 600-rpm compressors of which two cylinders each are high pressure, or second stage, and six cylinders are low pressure. Part of the refrigerant is delivered, through a heat exchanger and a supercooler, to the low-temperature coils in the rear section of the chamber. The remainder is directed through coils on the walls of the inner cylinder to provide a cold-wall barrier to thermal leakage through the insulation. The walls and the coil surfaces represent 10,000 square feet of heat-absorbing area. They are designed to remove 47,000 Btu per hour at 60,000 feet altitude and −55 degrees centigrade from the test load, 100 watts of lighting, and approximately 2 kw of circulating fan motor power, plus thermal leakage losses. At sea level, pull-down time from room temperature to design temperature is approximately four hours.

Temperature of the ambient air is maintained at desired values by a resistance-type recording controlling thermometer. Another instrument can record readings from 16 pickups distributed about the chamber, on walls, on test piece, on fan motor, or wherever such data should be collected. Specially designed resistance pickup points, housed in small stainless-steel bulbs and shielded from radiation, are used as sensing elements.

Of interest in connection with the low-temperature tests is the provision inside the chamber of electric heating elements. These units are to be used at the conclusion of a cold test to return the chamber to room temperature before it is opened to a moist warm atmosphere. This step will prevent the voluminous condensation of water which would otherwise take place.

Recirculation Design. The treatment of circulating air is carefully worked out to limit cumulative contamination as tests of long duration progress. Inside air is drawn along the walls, over the refrigerating coils, and past the in-bled air cooler by a 36-inch vane-axial fan mounted in the top half of the bulkhead which divides the chamber. The output is delivered directly to the front section above the work. The table tops and the floor are plated steel gratings which provide for easy mounting of test units an allow the circulating air to pass down to its return are below the floor level. Directly beneath the steel grating are 300 activated charcoal filters, arranged to pass all th circulating air. Mounted in sections and on racks, the can be easily removed for cleaning or replacement. I is felt that the filters, plus the cold coils, will render re circulated air satisfactorily free from contamination.

The circulating fan is powered by a 3-phase 60-cycle 4 pole motor rated three horsepower. It is of totall enclosed ball-bearing construction and draws power fron a variable-voltage variable-frequency motor-generator set At 1,660 rpm the rating of the fan is 25,000 cubic feet pe minute of air having 0.097 specific gravity (approximatel 80,000 feet) and at that point it dissipates 2.2 horsepower At sea level, the fan is rated 5,000 cubic feet per minut and draws 0.4 horsepower at 400 rpm. The motor generator delivers power over a frequency range of 13 t 60 cycles to match the fan requirements.

MECHANICAL SHOCK

SPECIFICATIONS *AN-M-40*[7] and *AN-I-10b*[5] require d-c motors and inverters to withstand 60 shocks, ten i each direction along the three axes. The value of th shock is specified as "10 *g*." Earlier specification *USAF 71-854*[3] called for ten shocks of 25-*g* intensity.

Specification *USAF-41065B*[2] reads: "The apparatus shal consist of a device........for mounting and giving linea acceleration to components through the following ranges:

175 *g* at a time duration of 0.003 second
40 *g* at a time duration of 0.010 second
15 *g* at a time duration of 0.015 second"

The first issue of *AN-E-19*[4] included a specification fo shock which reads as follows: "The equipment...... shall be designed so that no damage or maladjustmen shall result from 25 cycles of the following: maximun acceleration, applied in any direction of 8 *g* (257 feet pe second per second) developed at a constant rate in 0.

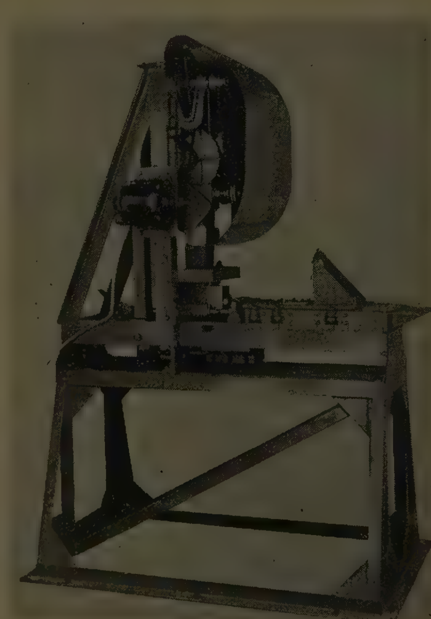


Figure 6. Standar "lightweight" Nav impact machine

econd and sustained for 3 seconds and the same acceleration developed at a constant rate in 0.05 second and educed to 1 *g* in an additional 0.05 second."

Few engineers understood it and the Armed Forces dmitted not being able to reproduce it. Amendment 1 ubstituted this requirement: "The equipment shall not uffer damage........when it is subjected to 30 impact hocks of 30 *g*, each shock impulse having a time duration of 11 ± 1 milliseconds." This specification is interpreted s meaning that the time for acceleration from 1 *g* to a maximum of 30 *g* and return to 1 *g* shall equal 11 ± 1 milliseconds.

Discussion of shock-testing techniques and equipment brought out many points of view but no prediction as to what the future might hold for aircraft components in this area of performance. It was concluded that a worthy objective was to understand the specifications and attempt to meet them in their current form. If new requirements arose, new equipment could be developed as needed.

The quotation marks around "10 *g*" were taken directly from the text of the specification. The reason for them, and for the numerous ways of specifying shock test, became more evident as the search for equipment developed. The impossibility of defining a shock independent of time had led to the use of "10 *g*" as a symbol without meaning. As had happened in other fields of application, the solution of this problem had assumed two phases: first, the definition of standard machines to describe the means of administering the shock; second, an investigation into methods of recording and repeating definite acceleration-time curves.

The standard machine which appeared to match best the requirements of the program was observed in operation both at Wright Field and at the Naval Research Laboratory. It is known as the "lightweight" or "electronic" shock machine and was developed by the Boston Naval District in conjunction with a manufacturer in Rhode Island. Several duplicate units were built and distributed for use as calibrated shock devices.

The anvil plate of this machine weighs 70 pounds. The test load can be approximately equal to that value. A 150-pound hammer can be dropped 36 inches to deliver the maximum blow.

The Navy machine is shown in Figure 6. It will be used in conjunction with acceleration-sensitive pickups which will record the time-acceleration characteristics of the shock effect on the unit undergoing tests.

Investigation of the control and reproduction of shock waves was taking place at Wright Field. A machine had been developed there which delivered the shock by dropping a platform carrying the test piece into a sand pit. Magnitude of accelerations and time of duration could be controlled by height of fall and configuration of blocks placed on the under side of the platform. Stopping times up to 100 milliseconds' duration had been recorded on an oscillograph by pickups attached to the device under test.

It was concluded that the Navy machine would satisfy current specification requirements and that a different machine could be obtained if and when specifications reflected new approaches to the defining and generation of shock waves.

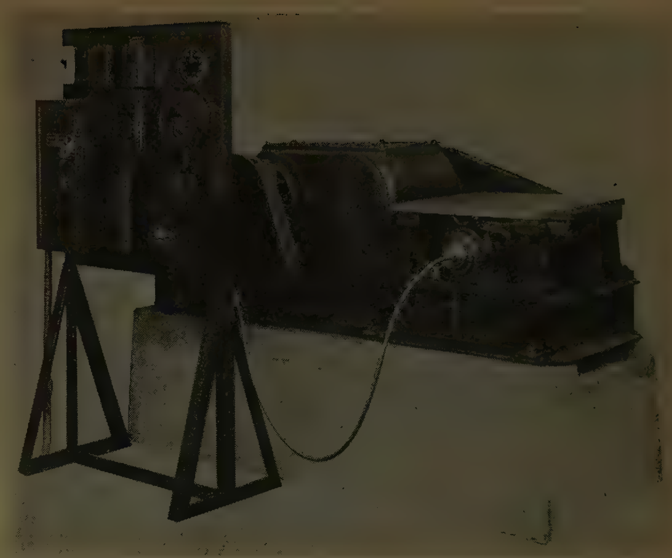


Figure 7. Mechanical vibration machine for the 0-to-100-cycle range

VIBRATION

Most official specifications define vibration tests in terms similar to the following excerpt from *AN-M-10a:*[6] "The motor shall be subjected to vibration consisting of simple harmonic motion, having an amplitude of approximately 0.03 inch (maximum total excursion of 0.06 inch), and a frequency varied uniformly between the limits of 10 and 55 cycles per second. The period of variation shall be from one to five minutes." Other specifications confine the period of variation to one minute. The latest motor specification *AN-M-40*[7] calls for an increased frequency range of 10 to 100 cycles per second. Inverters, on the other hand, need meet only 0.03-inch total excursion.

Specification *USAF-41065B*[2] paves the way for examination of vibration characteristics of aircraft components up to a frequency of 500 cycles per second at 20 *g* (0.00152-inch total excursion). This document also describes a method of test which is being used increasingly. The test piece is vibrated at low amplitude through a given range of frequency. Resonant points are determined by observation, and the piece is given extended tests at each such point.

Other specifications, written for components designed for specific applications, include long periods of vibration at single frequencies. A propeller pitch motor, for instance, must pass a 60-hour test at 240 cycles per second. Other devices are vibrated at 135 cycles per second.

Search for a design goal in the matter of vibration testing brought out the fact that knowledge about vibrations present in aircraft exceeded the ability of available test equipment to reproduce these conditions. For tests at single frequencies and small excursions, tailor-made exciters and resonant beam devices had been used with success. However, the problem of exploring a range of frequencies above 100 cycles per second, either in short steps or continuously, had not been solved. Although frequencies as high as 10,000 cycles per second had been recorded in operating aircraft, few applicable specifications actually involved range testing above 100 cycles per second. In-

Figure 8. Electromagnetic vibrators can be used to make tests up to 500 cycles per second

creasing specified ranges to 200 cycles was under official consideration. It was decided to purchase available vibration testing equipment and to keep abreast of the art as progress developed.

Investigation of equipment being used to make vibration tests on this class of equipment discovered two types of machines, mechanical and electromagnetic.

Mechanical Vibrators. Mechanical vibrators (Figure 7) are equipped with a table approximately 18 inches square on which the work to be tested is mounted. By means of belts and cams, an electric motor drives the table linearly or circularly at a specified excursion and frequency. Cam adjustments control excursion, while motor speed determines frequency. Early machines were developed to match the 0.06-inch 10-to-55-cycle specification in *AN-M-10a.*[6] They were equipped with a control which automatically produced the range cycling within the required one to five minutes. This "brute force" approach to vibration generation was rough on the testing machines and maintenance was fairly high. Even at 55 cycles the life of the early machines was limited. A new improved design was developed. It was of sufficient size to carry the weights involved and could be used to 100 cycles per second. An improved lubrication system and modified mounting of auxiliary equipment had rendered it a more acceptable device. It was decided to purchase one of these machines for this phase of the vibration testing program.

Electromagnetic Vibrators. Electromagnetic vibrators of the loudspeaker type were finding extensive use as exciters of resonant beams to obtain tests at fixed frequencies (Figure 8). Power supplies to drive the exciters up to 500 cycles per second were available, and point-to-point explorations of vibration resistance in that range could be made. The control problem involved in automatically testing at constant *g* variable amplitude over a range of frequencies is a complex one. So, too, is the constant-amplitude variable-*g* test. To date no such automatic control is available, but the exciter can be a useful tool under manual control.

For the purposes of satisfying immediate testing problems, it was concluded that the mechanical machine could be used for exploration and extended tests, including cycling, up to 100 cycles per second. The electromagnetic exciter could be devoted to explorations of performance at low amplitudes between 100 and 500 cycles per second. If it became necessary to make extended tests at specific frequencies in the range, the exciter could be used in conjunction with a resonant beam. The exciter is rated at 200 pounds thrust. The armature weighs ten pounds and can deliver maximum excursions of one inch. With a 10-pound load, the 10-pound armature can produce maximum accelerations of 10 *g*. For higher accelerations or appreciably larger loads, the use of resonant beams with the exciter is mandatory.

This phase of the test equipment program emphasized the urgent need for a heavy-duty adjustable or continuously variable resonant beam system. Used in conjunction with an electronically powered exciter and controlled by feedback from the operating bar, the combination would be useful as a cycling device in the region above 100 cycles per second. Furthermore, tests of long duration could be performed more readily.

At least two approaches to the problem have been initiated. One involves the use of bars and weights in which resonance is controlled by the position of the weights along the bar. The second is based on providing a variable-pressure compressed air cushion which acts as a controllable and continuously variable spring. The principle has been successfully demonstrated on a small model and some plans are under way to adapt it to systems involving test loads of 100 pounds.

CONCLUSION

ALREADY complex electrical, mechanical, and environmental performance requirements for electric rotating machinery designed for aircraft are continually becoming more involved. Only through the expenditure of many man-hours and much money can a manufacturer equip himself to evaluate completely his designs. Additional work is needed toward providing more exact methods for specifying and testing for the mechanical environments of shock and vibration.

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Predicting Phase Behavior With Digital Computers

T. J. CONNOLLY S. P. FRANKEL B. H. SAGE

OMMERCIALLY AVAILABLE digital computing equipment of the punch-card type[1,2] permits the expedi-ous direct application of relatively complex analytical ex-ressions to the evaluation of the conventional thermody-amic properties of pure substances and mixtures. In the ase of hydrocarbons, the Benedict equation[3,4] is of particu-r utility in describing the effect of pressure, temperature, nd composition upon the thermodynamic properties of a ystem. However, the complexity of such an expression akes this application time-consuming unless automatic omputing equipment is employed. Beattie[5] has outlined e general nature of the calculations associated with the valuation of the thermodynamic properties of homogeneous nd heterogeneous systems. These methods apply to ure substances and multicomponent systems alike.

At present it appears practical to utilize equations of ate to establish the desired thermodynamic properties of ure substances or mixtures at the time they are required r a particular application. A number of books would e required to record briefly the pertinent thermodynamic roperties of the pure substances of common industrial iterest, and a small library would be necessary to record e pertinent phase behavior and relevant thermodynamic roperties of mixtures encountered in industrial practice. he simple generalizations which have been proposed describe the behavior of components and their mixtures re inadequate for many purposes. The combination of utomatic digital computing equipment and suitable quations of state appears to be one means of obtaining alues of volume, enthalpy, and entropy as a function of ate for homogeneous systems and the composition of the oexisting phases in the heterogeneous region without the eed for extensive tabulations associated with the recording f such data. The use of equations of state represents a gnificant improvement in accuracy over that normally ealized with simple generalizations which usually are ased, at least in part, on the theorem of corresponding ates. The Benedict equation of state which is explicit pressure may be written in the following form:

$$=\frac{RT}{V}+\left[B_0RT-A_0-\frac{C_0}{T^2}\right]\frac{1}{V^2}+[bRT-a]\frac{1}{V^3}+\left[\frac{c}{T^2}\left(1+\frac{\gamma}{V^2}\right)\exp\left(-\frac{\gamma}{V^2}\right)\right]\frac{1}{V^3}+\frac{a\alpha}{V^6} \quad (1)$$

here P is pressure in pounds per square inch absolute, is the molal gas constant, T is temperature in degrees Rankin, and V is molal volume in cubic feet per pound of molecular weight. Parameters in the equation are A_0, B_0, C_0, a, b, c, α, and γ. Similar expressions of somewhat greater complexity based upon equation 1 are available to establish the enthalpy, entropy, and fugacity[6] of a phase as a function of volume, temperature, and composition.

Effective calculations of this nature involved the use of punch-card digital computing equipment[1,2] including the type-*604* electronic computing punch developed by the International Business Machines Corporation. It is possible to establish the volume, enthalpy, entropy, and fugacity of a phase in not more than five minutes of computing effort, providing the requisite background data are at hand. The latter information involves a knowledge of the several constants of the equation of state indicated in equation 1 and the requisite interaction coefficients for mixtures. Such information has been obtained for the lighter paraffin hydrocarbons[3,4] and a number of other compounds. The details of such calculations are available.[7]

The rather extensive iterative procedures required to determine the composition of the coexisting phases in the case of a ternary mixture involved about 40 minutes of computing time. It is probable that this period may be decreased as further developments are made on the computing equipment and techniques. These calculations include the determination of the thermodynamic properties of the coexisting phases as well as their composition. The use of a card-control calculator or a general purpose electronic computer would result in a substantial decrease in the time required for these iterative procedures.

The direct utilization of digital computing equipment to evaluate the phase behavior and the thermodynamic properties of coexisting phases at the time they are desired avoids the need of extensive tabular records and yields results of somewhat better accuracy than the generalized predictions presently available.

gest of paper **50-259**, "Application of Automatic Digital Computing Methods to the ediction of Phase Behavior," recommended by the AIEE Committee on Computing vices and approved by the AIEE Technical Program Committee for presentation the AIEE Fall General Meeting, Oklahoma City, Okla., October 23–27, 1950. Not eduled for publication in AIEE *Transactions*.

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Carbon-Pile Voltage Regulators

R. L. MILLS
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IN ORDER to determine the stability and transient characteristics of a system in which a carbon-pile regulator controls the voltage of a d-c generator, an analysis of the transfer function of the regulator has been made. The transfer function was defined in such a way that the regulator can conveniently be considered a linear amplifier in a feedback control loop. Also, the definition was chosen so that empirical measurements of the regulator transfer function would be feasible. Input and output variables are taken as changes from the initial operating points of operating coil voltage and carbon-pile resistance, respectively. By definition the transfer function of the regulator is the complex quantity $R(\omega)/e$.

The regulator transfer function can be derived by writing two linear differential equations, one for the electri circuit and one expressing the mechanical forces an motion of the regulator armature. One of the force involved is the pull of a magnet which depends upon bot operating coil current and a variable air gap spacing In order to keep the equations linear, it was necessary t expand the magnet force expression in a Taylor series fo two variables and discard all but first order terms, restrict ing the analysis to small armature motion and small cur rent changes. Final form of the regulator equations are

$$E = I(R_c + j\omega L) + j\omega X \quad (1$$

$$UI = X(K - \omega^2 M) \quad (2$$

where E, I, and L are the incremental voltage, current, an self-inductance of the operating coi circuit; R_c is the operating coi circuit resistance; X is the armatur incremental displacement; M i the effective mass of the arma ture; K is the difference in th slopes of the magnet and carbo pile force-deflection curves; and U is a magnetic coupling coefficient.

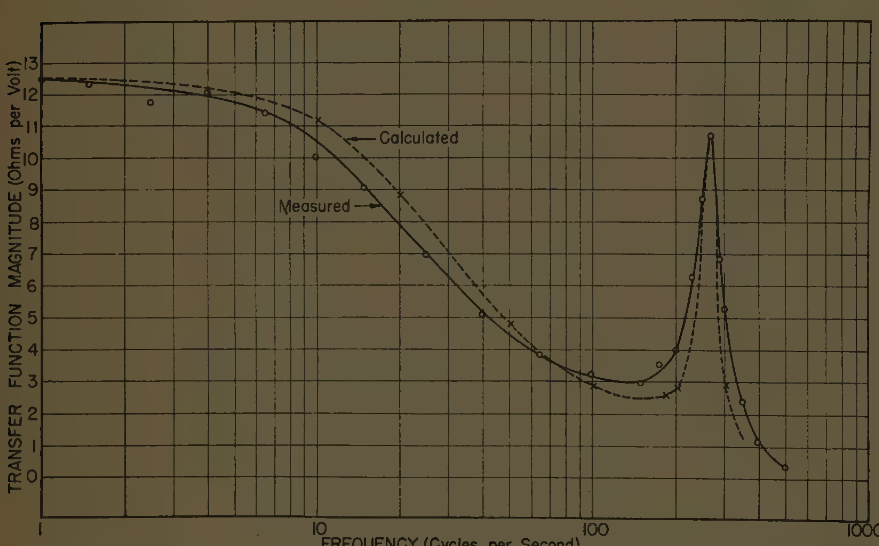

Figure 1. Magnitude of calculated and measured curve for a typical regulator

Equations 1 and 2 can be solve for the ratio of X to E. Multipli cation of the result by P, where P is the proportionality constant exist ing between armature displacemen and pile resistance, yields the de sired expression for the transfe function:

$$T_r = \frac{UP}{KR_c - \omega^2 R_c M + j\omega(KL + U^2 LM)} \quad (3$$

The magnitude of a calculated an measured curve for a typical regula tor is shown in Figure 1.

Measurements of the transfe function were carried out by mean of the electronic circuit shown i Figure 2. The carbon-pile resist ance is in the grid circuit of th first half of the *6SL7*, and draws con stant current so that the voltag across it is proportional to the car bon-pile resistance. The operatin coil current is controlled by a ban of *6AS7*'s.

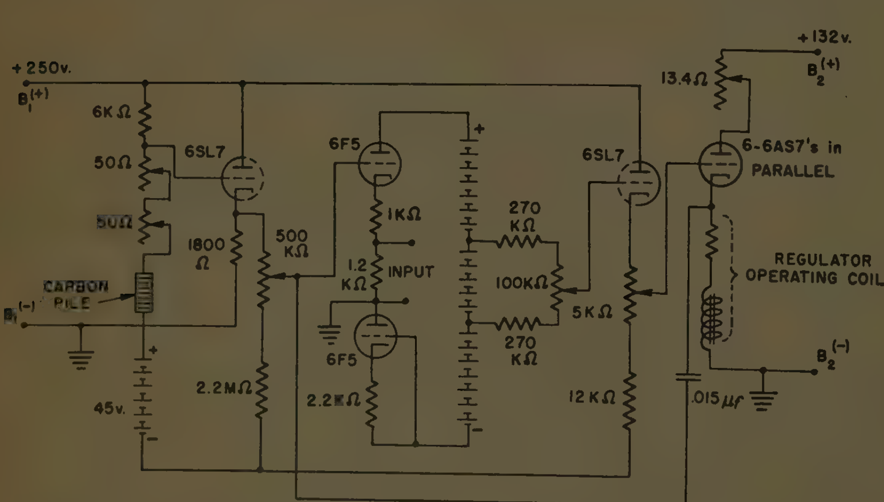

Figure 2. Electronic circuit used for measurements of the transfer function

Digest of paper 50-213, "Dynamic Characteristics o Carbon-Pile Voltage Regulators," recommended b the AIEE Committee on Air Transportation an approved by the AIEE Technical Program Com mittee for presentation at the AIEE Middle Easter District Meeting, Baltimore, Md., Oct. 3–5, 195 Scheduled for publication in AIEE *Transactions*, vo ume 69, 1950.

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A Negative-Impedance Repeater

J. L. MERRILL, JR.

A negative-impedance telephone repeater has been designed to reduce transmission losses on systems using tandem switching, or for toll connecting trunks and special service lines. The repeater, consisting of a transformer, an amplifier, and a network, has been arranged as a complete unit in itself, to simplify its installation.

IN SPITE OF the increasingly widespread use of carrier, coaxial, and radio . the long-distance plant of e Bell Telephone System, e basic transmission meum for distances of 20 miles less is the 2-wire circuit erating at voice frequencies. uch lines serve to link a subriber's telephone set to its associated central office and interconnect the various central offices within an area vering a city or a group of towns, known as an exange area. To improve transmission on these exchange ea lines a new type of device, the negative-impedance peater, has been developed.

As the nation has grown, the exchange area plant has en continually extended and rearranged to meet the anging conditions of the times. Shifts in population or mands for new or special telephone services have reired either that some additional device be developed improve transmission over existing lines or that new cilities having a lower transmission loss per unit length installed. One of the first devices developed to lower e loss per unit length of a copper-wire line was the loading il, and loading coils have found application in the change area as well as in the toll plant. Another device veloped to reduce circuit loss was the voice-frequency peater, which made the first transcontinental line feasible. owever, because of the amount of equipment which is cessary for 2-wire application, this type of vacuum-tube peater did not prove generally to be an economical swer to the problem of reducing line attenuation in the change area.

The negative-impedance repeater described here, desigated the *E*1 telephone repeater, has been designed ecifically for application in exchange area circuits. hile it has few parts, it is complete in itself; it contains the equipment necessary for direct insertion in a 2-wire e. Its package nature simplifies the equipment and gineering aspects of installation. There are no external cks, coils, or networks to be associated with the repeater hen it is installed.

The principal field of use of the *E*1 repeater appears to be on tandem trunks, toll connecting trunks, and special service lines. In an exchange area some central offices are connected directly with each other by means of direct trunks while others are connected together through an intermediate switching point known as a tandem office. As compared to direct trunking of all calls, tandem switching results in a smaller number of and more efficient trunk groups. However, tandem trunking involves greater distances than direct trunking and hence can require a lower loss per unit length of line. *E*1 repeaters may provide an economical means of reducing transmission losses on trunks from a distant office to tandem. Similarly, they may be used to lower the loss of a trunk connecting a local central office to a toll switching point. Also they may find important application where a subscriber requests a special telephone service and the use of already existing line facilities alone would result in poor transmission of the signals.

FEATURES

THE *E*1 repeater consists of three basic parts (Figure 1): a transformer, an amplifier, and a network. The transformer couples the amplifier to the telephone line through two balanced windings, one inserted in each line conductor. The amplifier is a feedback arrangement referred to as a negative-impedance converter because, in effect, it transforms the impedance of the network into a negative impedance. This negative impedance is inserted in series with the line by means of the transformer. The network is adjustable. Its impedance determines the voice-fre-

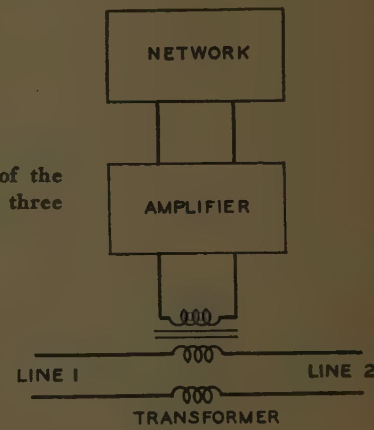

Figure 1. Block diagram of the E1 repeater showing the three basic parts

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e writer acknowledges the help of K. S. Johnson, F. B. Llewellyn, R. C. Mathes, C. Reier, and K. G. Van Wynen, all of the Bell Telephone Laboratories, in evolving concept of negative impedance expressed herein. He also acknowledges the conutions of W. J. Kopp and J. A. Weller, also of the Bell Telephone Laboratories, to theory and practical design outlined herein of the negative-impedance converter he *E*1 type.

quency gain introduced by the repeater, and no other gain control is provided.

No gain is provided for low-frequency signaling current. Direct current can pass through the line windings of the transformer with but slight impairment to d-c supervision (about 40 ohms). Ringing currents (20 cycles per second) and dial pulses pass through with moderate loss.

The Western Electric Company's *407A* vacuum tube used in the amplifier is a twin triode of the miniature type. The two heaters of the *407A* connected in parallel draw

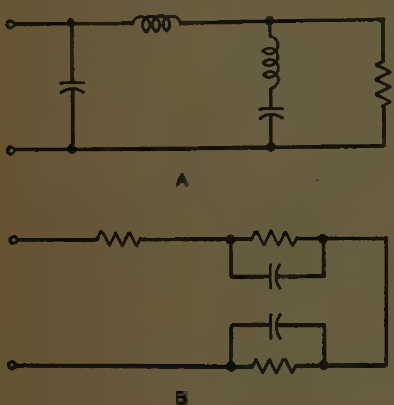

Figure 2. Typical network configurations for the E1 repeater

100 milliamperes from a 24-volt central office supply, or connected in series draw 50 milliamperes from the 48-volt supply (power drain in either case 2.4 watts). The plates operate at 130 volts and each one of the two draws 5.5 milliamperes (power drain for the two plates is 1.5 watts). For special applications with an a-c operated power supply a *2C51* vacuum tube can be operated with 6.3 volts on the heater and 130 volts on the plates.

The network contains a number of inductors, capacitors, and resistors which are brought out to terminals on a block under a can cover. Various impedance combinations are available depending upon the pattern in which these terminals are interconnected or "strapped." The strapping is determined by the type of line facility with which the repeater is to be associated and by the amount of gain required. Two typical network configurations are shown in Figure 2. Both the gain obtainable and the power handling capability of the *E*1 repeater are ample. The maximum usable gain (integrated over a voice-frequency range of about 300 to 3,500 cycles per second) is about 10 decibels. The gain at any one frequency may differ somewhat from this integrated value. Because of the impedance relationships found in the exchange plant, greater gain than 10 decibels would seldom be usable from any 2-wire repeater. The gain of the *E*1 is the same for both directions of transmission. The repeater will handle without noticeable distortion speech volumes of +10 volume units, and can be located at any point in a circuit since, with present telephone instruments at least, overloading is not a factor.

METHOD OF APPLICATION

For most telephone applications the *E*1 repeater can be considered as a negative impedance connected in series with a line. The action of the amplifier can be thought of as converting the impedance of the network to negative impedance which is coupled in series with the lin by means of the line transformer.

In general, a negative impedance inserted at random in line will provide a transmission gain by increasing th flow of current. It also will produce reflection effect These reflection effects can be reduced to tolerable propo tions by the expedient of limiting the amount of negativ impedance allowed under various circumstances, whic means limiting the repeater gain. When inserted in cable circuit a single *E*1 repeater can reduce the loss of line to about one-half of that of the line which does not hav a repeater without producing noticeable reflection effect However, more gain can be obtained from a repeater whe connected at about the middle of the line than can b had from the repeater when located at or near one enc Where a line consists of a nonloaded section of cable joine to a coil-loaded section, maximum permissible gain will b obtained, in general, when the repeater is located at th junction of these two line facilities.

When any lumped impedance, positive or negative, inserted in a smooth transmission line, reflection effec will result unless these effects are phased out in a wa similar to that used with coil loading. In general, the ter "loading" implies the methodical addition to a unifor transmission line of some impedance or impedances for th purpose of changing the transmission characteristics of th line. For the most part loading is applied for the purpo of reducing line attenuation. It also will change th velocity of propagation and the characteristic impedan of the line. Loading sections need not be of the sam length as long as they have about the same impedan where they are joined together; the preferred place is mid-section.

Loading with coils adds inductance and thereby reduc the attenuation of a line, decreases the speed of propagatio along it, and increases the magnitude of the characterist impedance seen at mid-section. Loading with negativ impedance can add negative resistance and inductanc This type of loading can be made to reduce line attenuatio increase the speed of propagation, at least at the low frequencies, and decrease the value of the mid-sectic characteristic impedance with reference to the chara teristic impedance of the nonloaded line. In general, th speed of propagation on lines loaded with negative im pedance will materially exceed the speed of propagatic of coil-loaded lines.

Because of the greater speed of propagation, the distan between loading points can be greater with negative-im pedance loading than it can be for coil loading for the sam band of frequencies transmitted. Furthermore, negativ impedance loading can reduce line attenuation below th possible with coil loading because the negative-resistan element supplies additional power to a line. At prese negative-impedance loading appears to be a side issue the main application of *E*1 repeaters which consists connecting a single repeater in a coil-loaded or a no loaded line. These repeaters will be located in convenie central offices.

As mentioned, an *E*1 repeater can be applied on the ba

t it is a 2-terminal negative impedance and as such can inserted in series with a telephone line or other imlances. Thus the repeater may be considered as conning two fundamental elements rather than the three ts shown in Figure 1. The repeater can be considered consisting of a positive-impedance network and a conter whose function is to multiply the impedance of the work by a factor which transforms this positive imlance into a negative impedance. The amplifier and nsformer of Figure 1 are both part of this negative-impedce converter.

THE NEGATIVE-IMPEDANCE CONVERTER

HE IDEA of negative impedance originated over 30 years ago, and was associated with the concept of istance neutralization. This concept was based on the t that a 2-terminal device containing a feedback ampli-, an electric arc, or some semiconductor inserted in ies with a single-mesh circuit, could produce the same rent flow as would flow otherwise were a resistance removed from this mesh. Thus, in effect, the device ıld neutralize[1] an amount of resistance equal to R. ithin certain frequency limits such a device could be ated as a negative resistance equal in magnitude to R. However, negative resistance cannot be completely sociated from reactance at many of the frequencies in band which must be studied in order to make certain stability. Consequently, the term negative impedance used herein to designate the effect produced by a 2-minal device which has the property of negative retance at some frequencies, negative resistance plus ıctance at other frequencies, and positive impedance at l other frequencies.

Heretofore, a number of feedback amplifier circuits have en devised for producing negative impedance. These cuits can be described as converting positive impedance o negative impedance. In general, they can be reduced an electrically equivalent 4-terminal network consisting a combination of positive-impedance elements together th an approximately ideal negative-impedance converter.

An ideal negative-impedance converter (Figure 3*A*) embles a form of transformer: it has a ratio of transmation of $-k$:1, can have four terminals, and is capable bilateral transmission. Assuming that a positive imdance Z_N is connected to terminals 3 and 4 and $-kZ_N$ een at terminals 1 and 2 (Figure 3*B*), it must follow from theory described herein that if a positive impedance is connected to terminals 1 and 2 a negative impedance $/-k$ will be seen at terminals 3 and 4 (Figure 3*C*).

George Crisson stated[2] that there are two types of negative pedance which he defined as the series type and the ınt type respectively. His series type is the reversedtage type of negative impedance $-kZ_N$ equivalent to E/I; and his shunt type is the reversed-current type $/-k$ equivalent to $E/-I$. This is a logical developnt considering that impedance Z equals E/I, and there-e negative impedance $(-Z)$ equals either $-E/I$ or $-I$ where E is the voltage measured across the imlance and I is current flowing through it.

A practical converter circuit can be represented by Figure 3*D*. A vacuum-tube circuit contains positive-impedance elements. Some of these will show up in the equivalent circuit on the left side of the ideal converter; others will show up on the right side of the ideal converter. This will be clarified in the discussion of the *E*1 circuit which follows. The equivalent circuit of any practical negative-impedance converter of this type can be represented by the equivalent circuit of Figure 3*D* which shows the positive-impedance elements associated with the vacuum tube in the form of two equivalent networks (N_1 and N_2) arranged one on each side of the ideal converter C having a transformation ratio of $-k$:1.

The circuit of the negative-impedance converter used in the *E*1 telephone repeater is a new converter circuit. It consists of a transformer, two triode tubes, a resistance-capacitance network, and an inductor (Figure 4*A*). The transformer T couples the cathodes of the two tubes to terminals 1 and 2. The tubes work in push-pull and are biased for class-*A* operation. The resistance-capacitance

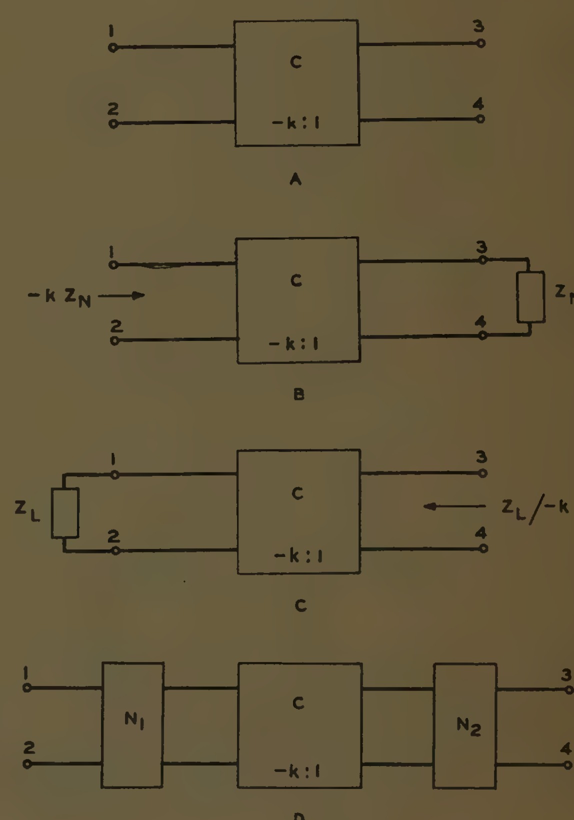

Figure 3. The negative-impedance converter. (A) The ideal converter; (B) Impedance seen at terminals 1 and 2; (C) Impedance seen at terminals 3 and 4; and (D) Equivalent circuit of practical converter

network couples the plate of each tube to the grid of the other. The inductor L supplies plate current.

By the application of circuit theory, an equivalent circuit for Figure 4*A* can be found (Figure 4*B*). In obtaining this equivalent circuit the two tubes have been assumed to be identical. Thus the converter used with the *E*1 repeater can be reduced to a 4-terminal network consisting of (reading from left to right): the equivalent circuit of the

line transformer T; the two biasing resistances R_2; the two plate resistances R_p divided by $(1+\mu_2)$; the ideal negative-impedance converter C of ratio $-(\mu_1-1)/(\mu_2+1)$ to 1; the elements in the resistance-capacitance coupling arrangement which appear in shunt across terminals 3 and 4; the inductor L also shunted across these terminals; and the capacitor C_X which has been added to represent both the distributed capacitance of the windings of L and the capacitance between vacuum-tube plates.

It should be noted that μ_2 is the amplification factor of each tube; and that μ_1 equals $\beta_1\mu_2$ where β_1 is a proportionality factor representing the fraction of the voltage, between the plate of one tube and ground, which is fed back to the grid of the other tube. The value of β_1 depends upon the values of C_1, R_3, R_5, and C_2 of the resistance-capacitance coupling circuit. If β_1 approaches unity in value, then μ_1 approximates μ_2. If this is so and if both μ_1 and μ_2 are relatively large in magnitude compared to unity, then the ratio of transformation, $-(\mu_1-1)/(\mu_2+1)$ to 1, approaches although it can never equal $-1:1$. Fu thermore, at both high and low frequencies μ_1 will have definite phase angle.

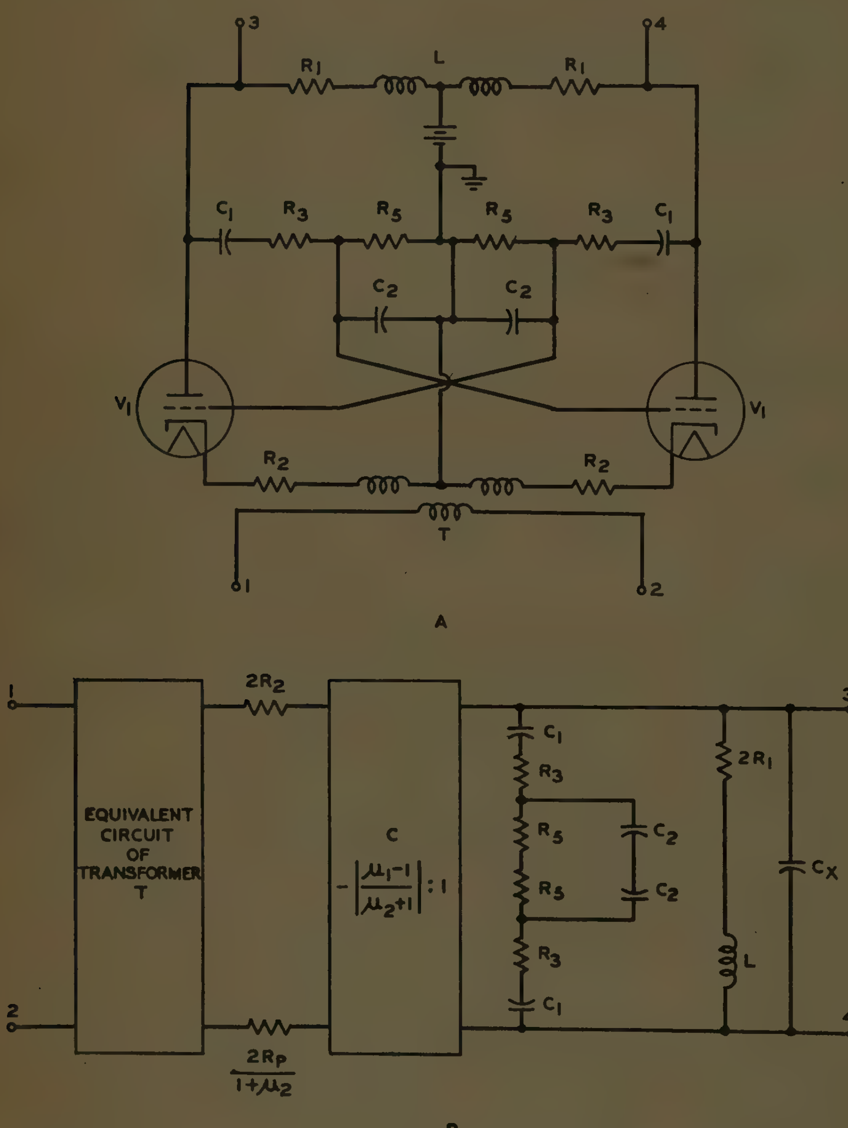

Figure 4. (A) Schematic and (B) Equivalent circuit for the E1 converter

With reference to Figure 4B, it may be obvious ho most of the positive impedance terms come to be in th equivalent circuit, but the factors $-(\mu_1-1)/(\mu_2+1)$ an $2R_p/(1+\mu_2)$ may require more explanation. While n attempt will be made here to derive the equivalent circu (Figure 4B), some idea as to how these factors, which ar essential features, happen to appear in feedback circuits this type can be had from a study of Figure 5. This figur represents a simple single-tube circuit similar to the E circuit. The line coil has been removed for simplicit as well as one of the vacuum tubes. To terminals 1 and has been connected an impedance Z_L and to terminals 3 and 4, an impedanc Z_N. The voltage e is an a-c voltage ap plied in series with impedance Z_L The instantaneous polarity of voltage is as shown, and it is assumed that th current i caused by this voltage wi flow in the direction indicated at th time under consideration. Let μ b the voltage gain of the tube, R_p b the plate resistance, and β:1 be th voltage ratio of the ideal transforme inserted between the grid and the plat of the tube. Furthermore, let it be as sumed that the tube is operating clas A and no grid current flows, and th result is a simple series circuit throug the cathode and plate of the tube The effect the grid will have on thi flow of current will be to multiply th voltages appearing between cathod and grid by the amplification factor and to add these voltages in series i the simplified circuit. The voltage between cathode and grid are: th driving voltage e itself, the voltag drop across Z_L (iZ_L), and the voltag drop across Z_N as seen across the trans former windings in series with th grid (the voltage $i\beta Z_N$). The voltag iZ_L, being a voltage drop, would b considered as having a sign opposite t that of e. The voltage $(i\beta Z_N)$ is as sumed to have the same sign as e an the polarity of the coil windings of th ideal transformer can be arranged t make this so. Thus the action of th tube grid can be replaced by a vol age of $\mu(e-iZ_L+i\beta Z_N)$. Therefor the simplified circuit of Figure 5 can be substituted for Figure 5A, an a solution can be found as shown for the impedance seen looking into terminals 1 and 2.

$$Z=\frac{R_p}{1+\mu}-\frac{(\mu\beta-1)}{(\mu+1)}Z_N \qquad ($$

Thus, looking into terminals 1 and 2 there is seen an npedance $R_p/(1+\mu)$ in series with an impedance Z_N which is multiplied by $-(\mu\beta-1)/(\mu+1)$, the transforma-on ratio of an ideal converter. The transformation ratio an be expressed as $-(\mu_1-1)/(\mu_2+1)$ to 1. In one sense his transformation ratio represents the action of both ositive and negative feedback. If μ_1 approximates μ_2 n both magnitude and phase and if this magnitude is large ompared to unity, then the transformation ratio would be elatively independent of variations in μ.

As an illustration of how the elements in this type of ircuit may be proportioned, the *E*1 design may be con-idered. Here the ratio $-(\mu_1-1)/(\mu_2+1)$ to 1 is $-0.9{:}1$ ver most of the voice-frequency range. This is not the ver-all ratio of transformation of the device, but only the atio of the ideal converter *C* (Figure 4*B*). The impedance atio of transformer *T* and the effect of the other circuit lements must be considered in determining the over-all ffect of the converter from terminals 1 and 2 to terminals and 4. The transformer ratio is 1:9 from terminals 1 nd 2 to the tube cathodes. The shunt arms of the net-vorks on both sides of the ideal converter *C* are relatively igh compared to the impedances between which this onverter has been designed to operate at voice frequencies. Therefore, these shunt arms can be disregarded at voice requencies, although at frequencies above and below the oice band they represent a problem for the circuit designer rom the viewpoint of circuit stability. The series arms uch as $2R_p/(1+\mu_2)$ and $2R_2$ could be cancelled out by dding in series on the right side of the ideal converter a esistance of 1,800 ohms (not shown in Figure 4). The inal result is that the impedance, seen looking into termi-als 1 and 2 of the *E*1 converter when 1,800 ohms plus a etwork Z_N is connected to terminals 3 and 4, equals $-0.1\ Z_N$ within a reasonable percentage of error over the requency range from about 300 to 3,500 cycles per second or values of negative impedance from about 100 to 2,000 hms. Actually this multiplying factor of -0.1 has a light phase angle at frequencies other than about 1,000 ycles per second which must be taken into account for etailed design work.

In the *E*1 design two line windings instead of the one hown connected between terminals 1 and 2 in Figure *A* are provided on transformer *T*. In practice one of hese windings is inserted in each side of the telephone ne in a balanced arrangement. Terminals 1 and 2 are hus effectively connected in series with the line and the 1 repeater inserts in the telephone line a reversed-voltage ype of negative impedance ($-E/I$), which is the means of ntroducing additional power in the line, thereby providing transmission gain.

STABILITY

IKE ANY amplifier whose output connects back to its input, the negative-impedance converter can run way with itself and oscillate if not properly terminated. ortunately, the criterion for determining stability is mple. Consider again the ideal converter (Figure 3*B*). ssume that Z_L, not shown on Figure 3*B*, is an impedance onnected to terminals 1 and 2. Consider the circuit mesh formed on the left side of the ideal converter by the connection of Z_L to terminals 1 and 2. Here a negative impedance ($-kZ_N$) is seen looking into terminals 1 and 2, and a positive impedance (Z_L) is seen looking away from them. The total impedance in this mesh is Z_L-kZ_N. If kZ_N should equal Z_L then the total impedance would be zero; and a voltage inserted in series with this mesh would call for infinite current, a situation obviously impossible. Thus it becomes evident that kZ_N should not equal Z_L; or, what is the same thing, the ratio kZ_N/Z_L should not equal $1\underline{/0}$ if the system is to be stable. From a practical engineering viewpoint, a simple rule for judging stability

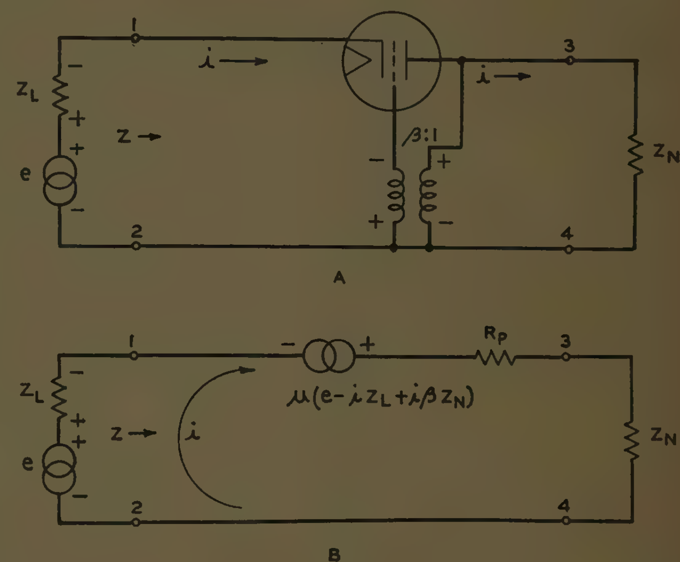

Figure 5. Operation of the E1 converter

(A) Schematic

e $=$ *a-c applied voltage*
i $=$ *current flow resulting from e*
β $=$ *voltage ratio of transformer*
$Z_L =$ *line impedance*
$Z_N =$ *network impedance*

(B) Simplified circuit

μ $=$ *voltage gain of tube*
R_p $=$ *plate resistance of tube*
Neither grid nor transformer draws current

$$e+\mu[e-iZ_L+i\beta Z_N]=i(Z_L+R_p+Z_N)$$
$$[e-iZ_L][\mu+1]=i[R_p+Z_N(1-\mu\beta)]$$
$$Z=\frac{e-iZ_L}{i}=\frac{R_p}{1+\mu}-\frac{Z_N(\mu\beta-1)}{\mu+1}$$

can be stated as follows: the ideal negative-impedance converter will be unconditionally stable provided that the magnitude of kZ_N/Z_L is less than unity at any frequency where the angle of this ratio is zero.

This same rule for stability applies to any practical converter circuit. However, Z_L must be taken as the impedance seen looking into the network N_1 from the position of the ideal converter *C*, and Z_N must be taken as the impedance seen looking into network N_2 from the ideal converter *C*. In other words, the effect of N_1 must be included in Z_L and the effect of N_2 must be included in Z_N. The proper handling of N_1 and N_2 to insure

inherent stability of a negative-impedance converter is the job of the circuit designer just as the elimination of parasitic oscillations of any kind is his concern. The engineer who applies these devices in the field does not have to bother with such details.

IMPEDANCE CHARACTERISTICS

FIGURE 6 presents an example of an impedance characteristic of the $E1$ repeater (Figure $4A$) as viewed from terminals 1 and 2 with a resistance connected to terminals 3 and 4. The impedance locus is plotted on the resistance-reactance plane. Frequency is taken as the "running" parameter and the impedance is presented for the frequency range from zero to infinity. At zero frequency this impedance would be a small positive resistance equal to the d-c resistance of the primary windings of transformer T.

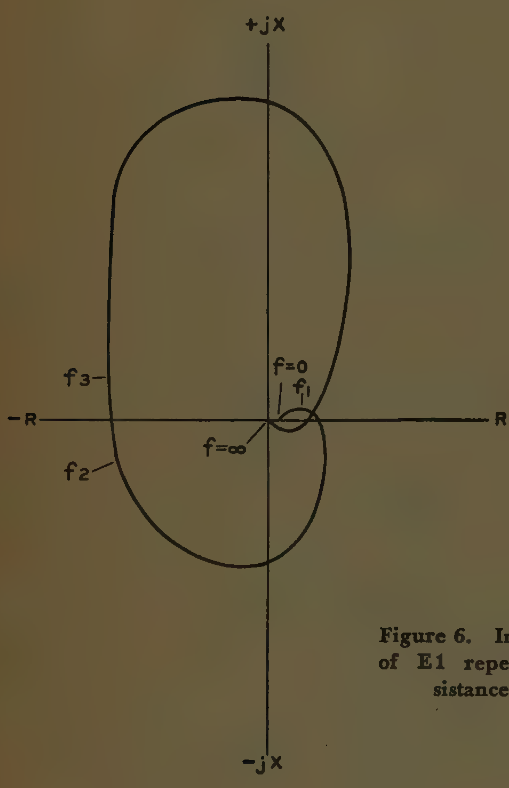

Figure 6. Impedance locus of E1 repeater with resistance network

At some low frequency f_1 (Figure 6) the locus would show a positive impedance. In the $E1$ repeater it is this portion of the impedance characterisitc which is used for the passage of low frequencies such as ringing, dialing, and the like. Between the frequencies of f_2 and f_3, Figure 6, is seen an impedance which approximates a negative resistance. This is the operating frequency range of the repeater. At high frequencies the locus would approach the origin again. In Figure 6 this approach is shown through the first and then the fourth quadrant. At frequencies above the speech band passed by the telephone line a negative impedance is not wanted. From Figure 6 it can be observed that if a resistance R is connected to the network terminals (3 and 4) of a negative-impedance converter, then, between frequencies f_2 and f_3 which define the operating frequency range of the device, the impedance seen at terminals 1 and 2 can be represented by hR wher h is a conversion factor having an angle approximatel equal to 180 degrees. The factor h includes not only th effect of the transformation ratio $-k$:1, but also the effec of the positive-impedance networks in the converter pro vided that the impedances between which this 4-termina device is operating are within the range of impedance between which it has been designed to operate. In thi respect the negative-impedance converter is like a trans former. Furthermore, if a network having an impedanc Z_N is connected to terminals 3 and 4, then at terminals and 2 will be seen an impedance which is equal to hZ_N which will be a negative impedance between the frequen cies f_2 and f_3.

The question of stability becomes a relatively easy prob lem in the application of a properly designed negativ impedance of the reversed-voltage type. If the networ used with the converter is designed to have an impedanc characteristic similar to the sum of the two line impedance (line 1 and line 2 of Figure 1) and if the magnitude of th sum of these two impedances is greater than hZ_N at all fre quencies, the system will be stable. It should be note that h is the conversion factor only for the band of fre quencies between f_2 and f_3. However, in a properl designed converter the magnitude of the negative rea component of h will be greater within this band of fre quencies than it will be outside this band. Hence, an error in the assumption that h applies at frequencies outsid the band defined by f_2 and f_3, in most cases, will be on th side of increased stability.

CONCLUSIONS

A REPEATER having the properties of a negative imped ance converter can be used in a telephone line for th following purposes:

1. To decrease the transmission loss of a line by th application of a single repeater. This is accomplished wit negative impedance by cancelling, in effect, part of th line impedance, thus causing an increase in current flow Of course, the magnitude of the negative impedance shoul be kept below the value where reflection effects becom noticeable. It is expected that most applications will b of this kind where a single $E1$ repeater is used on a tande trunk, a toll connecting trunk, or a special service line.

2. To load a line with negative impedance. By thi means it is possible to produce a low-loss line withou reflection effects.

3. To eliminate a lumped impedance irregularity equa to Z by the series addition to it of a negative impedanc equal to $-Z$.

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Light Steel Tower Line Designs

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THE NEW LIGHT STEEL tower line designs recently adopted by the Bonneville Power Administration 3PA) brought estimated savings in excess of 12,500 tons of eel and $4,000,000 during the first two years of practical oplication. These designs resulted from engineering udies begun during World War II to save critical steel, nd continued during postwar years in order to comat the sharp rises which have taken place in transmison-line construction costs.

The BPA system, embracing the Pacific Northwest eyond the Continental Divide, covers areas of widely arying terrain and climatic conditions. More than half this system is of steel tower construction. It was logical, ierefore, that early efforts to reduce transmission-line osts be directed toward developing more economical eel tower line designs. This end has been achieved y BPA engineers through application to steel tower conruction of principles ordinarily used in designing woodole structures.

Two types of structures were singled out in developing ie new light steel designs. The first was the tangentispension tower because it constitutes a gross average of) per cent of all the line structures in the BPA system. he second was the dead-end or anchor-strain tower, ecause this type is the costliest of all line structures to uild.

The tangent-suspension structures developed under the ght steel design principle do not differ in outward apearance from the standard self-supporting towers of the otated type commonly used by BPA. They have been esigned for, and have been found, in full-scale factory ests, to be capable of sustaining all standard vertical and ansverse loads, at designed factors of safety, which are enerally required by industry and applicable codes for ie specific terrain and climatic conditions prevailing in ie Northwest.

However, even though these towers were not designed take longitudinal forces resulting from broken wire onditions such as are prescribed in standard designs, sts have shown them capable of resisting longitudinal rces much greater than contemplated in the design age.

Dead-end structures designed under the light steel rinciple are no longer self-supporting rotated towers quiring heavy and expensive foundations. They are ttice-pole frames so designed as to be capable of withanding the vertical forces resulting from the standard esign condition of all conductors broken on one side of ie structure. Like their wood-pole counterparts, they are properly guyed to resist the longitudinal and transverse strains resulting from these standard requirements of line breakage.

When the newly designed light steel structures of the tangent-suspension and dead-end types are combined in a transmission line with other standard steel structures (such as those required for long spans, utility crossings, and so forth) the result is a light steel tower line. Such a light steel tower line differs outwardly from a BPA standard steel line only in the shape of its dead-end, heavy-angle, and transposition structures. A line so designed results, however, in economy of initial construction which closely approaches that of wood-pole lines, while affording the advantages of minimum maintenance and long life which are usually only associated with steel tower construction.

Light steel tower lines have their limitations, of course; therefore, they must be used only under conditions of terrain and climatic conditions corresponding to these limitations. Nevertheless, over 600 miles of light steel tower lines containing 2,300 light steel structures have been designed by BPA engineers since 1948 for carefully selected locations. These lines were designed to carry aluminum-cable steel-reinforced conductors equivalent to both 500,000 and 800,000 circular mils of copper. Lines designed for the larger conductor embody insulation and clearances which would be suitable for possible future operation at 287 kv.

The first light steel tower line was energized only several months ago; others are now under construction. Therefore it is too early to draw any operating conclusions on the performance of this type of design. There is, however, every reason to believe, especially because of the care with which their locations have been selected, that the newly designed light steel tower lines will provide the same nearly trouble-free mechanical performance as has been enjoyed by BPA in operating its standard steel lines over the entire period of the system's existence. Future lines of the BPA through areas free from severe icing and lightning will be predominantly of the light steel design. This does not mean that BPA studies and explorations in the field of structural and mechanical design, as related to high-voltage lines, will not continue. Studies now are oriented toward further perfection of the light steel designs for conductors 800,000 circular mils copper equivalent and larger.

There are also studies in progress for lines of higher voltages than 287 kv, both in standard steel and light steel designs, as well as for single and bundle conductors. Investigations have been started toward the development of steel structures which would permit a practical combination of the light steel idea, with the need for overhead ground wire protection in areas where there is high lightning frequency.

gest of paper 50-243, "Light Steel Tower Line Designs," recommended by the AIEE mmittee on Transmission and Distribution and approved by the AIEE Technical ogram Committee for presentation at the AIEE Fall General Meeting, Oklahoma ty, Okla., October 23–27, 1950. Scheduled for publication in AIEE *Transactions* lume 69, 1950.

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Simplified 48-Channel Carrier Telephone System

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THE SINGLE-SIDEBAND suppressed carrier method of deriving multiple communication channels from a common transmission medium is now almost 40 years old. The first systems to provide good telephone circuits by this method came into widespread use in 1927, followed by large scale installation of 3-channel systems about 1933. By 1938 12-channel systems had been applied to trunkline telephony, and soon thereafter equipment was available to provide really large numbers of channels over a coaxial cable. Current developments include the application of radio relay to the telephone plant and carrier systems designed for simplification of application and reduction of equipment cost.

The communication industry now is reasonably well standardized on 4,000-cycle separation for telephone channels having the transmission quality attendant to a bandwidth of at least 3,000 cycles. To achieve such spectrum economy and performance in systems having many bands translated to positions one above another, relatively costly crystal filters were brought into use. The design of a system which affords 3,400 cycles of bandwidth per channel, while employing relatively simple and inexpensive inductance-capacitance filters, marks a definite advance, particularly for short-haul wire line and radio applications. Also noteworthy is the reduction in number of vacuum tubes to approximately five per 2-way circuit.

This new 48-channel carrier telephone system employs two successive stages of modulation to accomplish frequency translations for each channel. With this method the first stage of modulation utilizes an 8-kc carrier frequency, and the upper sideband is selected for transmission. Regardless of its ultimate frequency allocation, each channel is positioned initially at an intermediate frequency band between 8 and 12 kc. Filters having very desirable characteristics can be built in this range of frequencies, and since one filter only need be designed for all channels, care can be taken to obtain optimum characteristics. Since the filters required in the subsequent stage of modulation will have broader passband characteristics, the passband of this first filter will determine to a large degree the response characteristics of all channels derived by this method, and this characteristic is substantially uniform from channel to channel.

Subsequent to initial modulation, higher frequency modulators are used to accomplish frequency translations between the intermediate frequency band and the final line frequencies of 12 to 204 kc. In this way, up to 48 channels may be assembled on 4-kc spacing with guard bands of only 600 cycles between channels; yet the high-frequency modulators and filters only need to meet the design requirements for a system having a guard band of 16 kc between channels.

In order to conform to accepted carrier system standards and for mechanical convenience, channels of the type-*42* system ordinarily are assembled as required, each rack having a normal capacity of 12 channels. Each rack is essentially a self-contained 12-channel assembly with voice frequency and common equipment jackfields, hybrid terminating networks, fuse panel, amplifiers, and terminal blocks being provided. Space is also available on the rack for pilot regulator equipment used when 2-wire operation of a 12-channel system is required. The equipment is designed for operation on 24- and 130-volt central office battery supply, but 110-volt power supply panels can be applied readily when required.

The following items determine the electrical performance of the type-*42* system:

1. Use of high-stability oscillators insures that frequency changes from input audio to output audio do not exceed about ten cycles over long periods of time.

2. Since the intermediate-frequency filters determine almost exclusively the attenuation characteristic within the voice channel, this performance characteristic is essentially uniform for all channels. For a typical channel the over-all equivalent of the voice band does not deviate more than about 0.5 decibel from the 1,000-cycle reference point throughout the range from 200 to 3,500 cycles.

3. Weighted residual noise power in a typical channel of the type-*42* equipment (all other channels idle) is about 75 decibels below one milliwatt. Long time average interchannel crosstalk and noise from all sources does not exceed a weighted power level of about 67 decibels below one milliwatt.

With a complete range of channel allocations from 1 to 204 kc available, equipment assemblages are readil made up to provide all the groups commonly needed t co-ordinate with existing carrier systems of any type. Fo example, a 12-channel system can be assembled with th allocations and directional separation as standardized fo the widely used type-*J* carrier. On cable circuits wher effectively isolated transmission paths are available, one o more 12-channel groups may readily be operated, the firs group using the 12-to-60-kc allocation.

For radio link applications, any desired grouping c channels is readily available. If the linearity of the radi system permits, up to 48 channels would be possible on single link. Often, however, due to intermodulatio distortion in the radio equipment, channel allocations c from 60 to 108 kc for 12 channels or from 100 to 196 k for 24 channels yield certain advantages in signal-to-nois ratios.

Digest of paper 50-240, "A Simplified 48-Channel Carrier Telephone System," recommended by the AIEE Committee on Wire Communication Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Oklahoma City, Okla., October 23–27, 1950. Scheduled for publication in AIEE *Transactions*, volume 69, 1950.

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The Magnetic-Particle Power Clutch

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The magnetic clutch is now in use in many different fields. With proper design it can be adapted for use with 1,000-horsepower installations as well as with those of fractional horsepower.

IN OCTOBER 1948 Jacob Rabinow[1] of the National Bureau of Standards described the invention and the very thorough preliminary development of a new clutch based on the principle of filling the air gaps between the clutching surfaces with a mixture of very fine iron powder and oil, this mixture being excited by an electromagnet coil and core structure. The "viscosity" or resistance to movement was directly proportional to the coil current, thereby providing a controllable torque and nonwearing clutch with no mechanical movable parts for actuation. In the months following Mr. Rabinow's announcement, a number of these clutches were developed for various purposes. Most of them, however, were small and usable only for intermittent duty. There were various restrictions on their use due to overheating and loss of oil, which caused a deterioration with age. The Navy saw great possibilities in the magnetic-particle clutch and placed orders for motor-generator sets using the clutch to control the speed of a 400-cycle alternator when driven from a 60-cycle induction motor supplied by slightly variable frequency. These motor-generator sets ranged in size from $2^1/_2$ kw to 25 kw.

There are two major considerations which determine the size of a clutch of this type. The first, of course, is the amount of torque which it must develop, and the second is the amount of heat which it must dissipate. The clutch is not a torque converter, and the power output differs from the power input by the ratio of the output to the input speeds. Since the clutch must hold generator frequency to ±0.05 per cent with a variation of input frequency to the drive motor of +5 per cent and $-2^1/_2$ per cent, and also take into account the 2-per cent slip of the induction motor due to load, it was necessary that clutches for that service have the ability to dissipate 10 per cent of their power when slipping under the most adverse conditions. It immediately became apparent that the size of these clutches would be determined completely by the heat-dissipating ability and that there would be no difficulty in providing sufficient torque.

The specifications for one of the motor-generator sets called for 3,428-rpm generator speed. Because of the heat-dissipation area required, it was necessary to use a very high peripheral speed in the clutch gap. Early experiments indicated that packing difficulties would be encountered on a disc clutch if operated at 3,428 rpm with a 9-inch diameter, the centrifugal force throwing the iron particles to the outer parts of the clutch until the two members were firmly wedged together. This difficulty was overcome successfully by using a cylindrical gap and reducing the quantity of magnetic medium to slightly less than enough to fill the gap when thrown to the outer periphery.

In order to eliminate loss of liquid due to any cause such as defective seals, centrifugal force, or excess heat, a nonliquid magnetic medium was used. With the dry medium, little trouble was expected with shaft seals. However, to minimize any possibility of difficulty, an arrangement of machined grooves or flingers was used on each side of the clutch so that even upon stopping and starting little or none of the medium could fall into the center around the shaft seal.

Figure 1 shows the clutch developed for a 5-kw motor-generator set. The clutch mounts on the shaft and the brush yoke on the face of a National Electrical Manufacturers Association Type-*C* induction motor. This was the unit first developed, and samples have been on en-

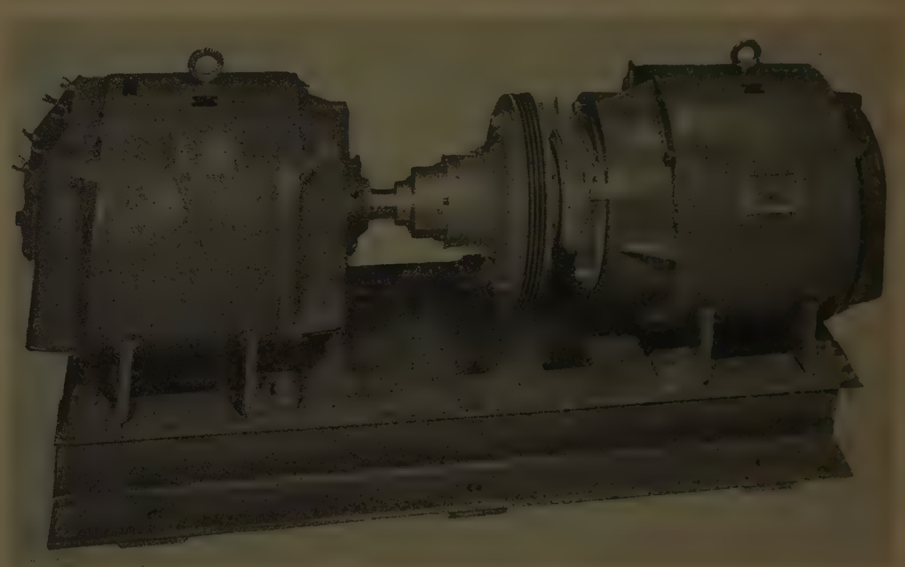


Figure 1. A 5-kw motor-generator set using Magneclutch for holding constant frequency

P. H. Trickey and W. G. Martin, III, are with Vickers, Electric Division, St. Louis, Mo.

durance run under various duty cycles for more than a year. A substantial first order for sets has been completed, and a number of them have been installed and in use for many months. So far neither life tests nor actual field use have shown any indication of wear, loss of torque, or detrimental effects whatsoever. This particular clutch will be used on both the 5-kw and $7^1/_2$-kw sets and will dissipate continuously about 750 watts.

Figure 2 shows a cross section of this clutch illustrating the use of a cylindrical gap, flingers, and shaft seals, and Figure 3 shows the performance curves of the *32D24* Magneclutch.

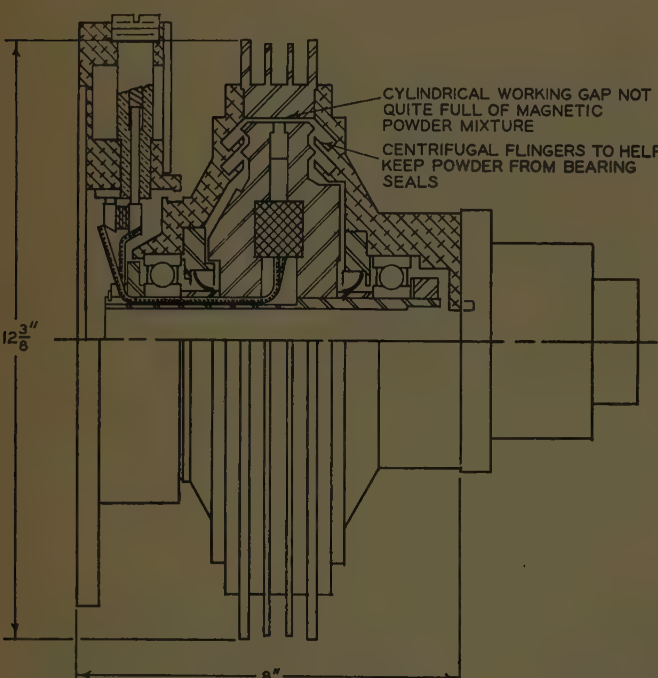
It is not necessary, of course, to use the cylindrical gap design on slow-speed clutches where the centrifugal forces are too low to cause packing. The design shown in Figure 2 has the excitation coil on the internal member. It can be placed just as readily in the external member when desirable.

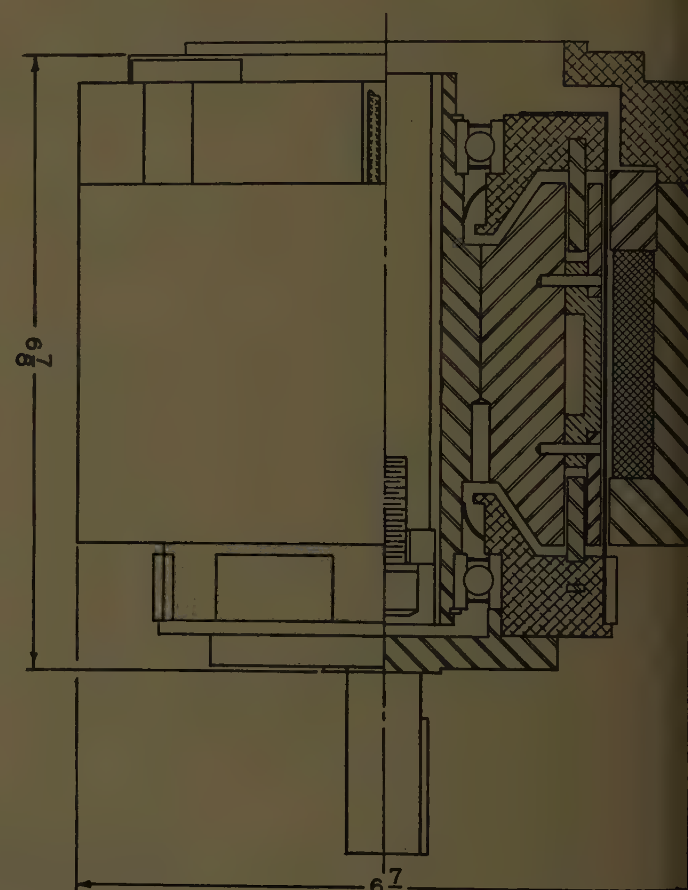
Figure 4 shows a multiple-cylindrical-gap type of clutch which was developed for high-torque low-speed service where the cylindrical feature was used not to eliminate packing but to provide ease of assembly. Figure 5 shows the performance curves of this clutch.

Figure 6 shows a cross section of a design illustrating the use of a stationary excitation member and the elimination of slip rings. This type of design takes more excitation power but eliminates the brushes and collector rings.

Figure 7 shows the cross-sectional view of a small clutch which was originally designed for on-and-off service but which will dissipate about 100 watts when it is used for slip service.

The clutch for the 25-kw set is expected to take the form shown in Figure 8, illustrating the use of a double-coil yoke. This clutch will be cradle-mounted because of its weight. This clutch was developed for 10-per cent slip service but when used for on-and-off service could handle





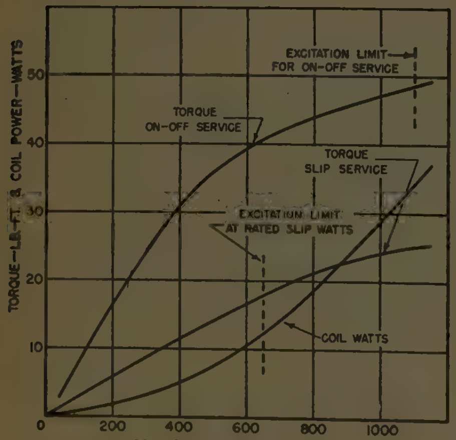
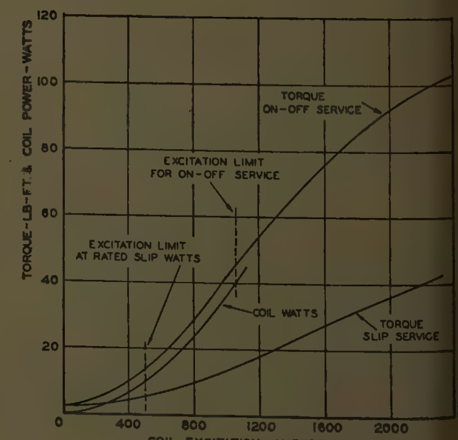


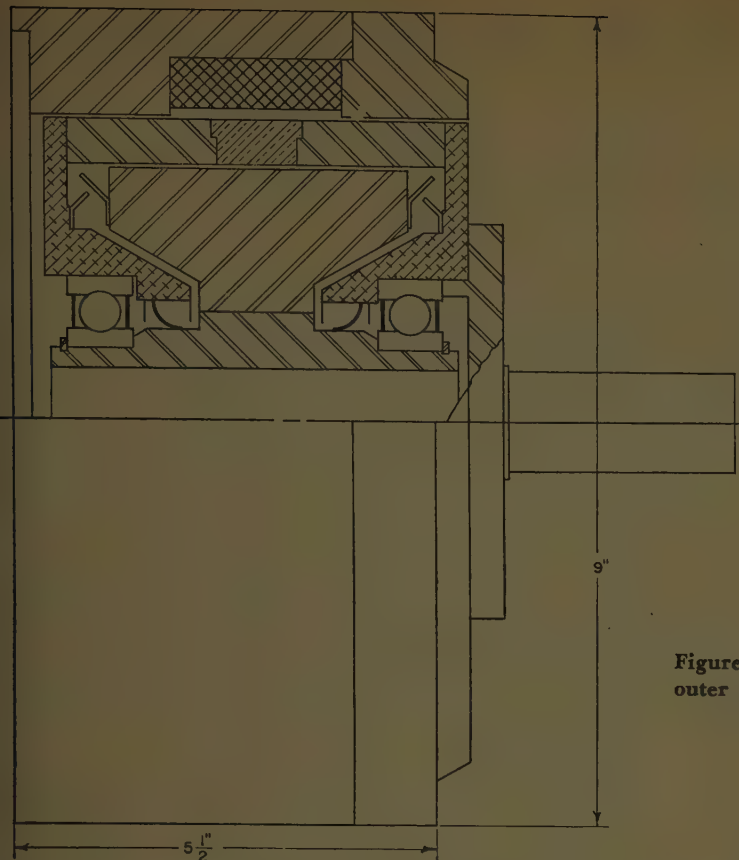
Figure 2 (above, left). Cross section of the Magneclutch shown in Figure 1

Figure 3 (below, left). Performance curves of the *32D24* Magneclutch

Figure 4 (above, right). High-torque Magneclutch used for power take-off from truck engine, on-off duty, slow speed

Figure 5 (below, right). Performance of Magneclutch of Figure 4





igure 6. Magneclutch without slip rings used for $2^1/_2$-kw motor-generator set for constant frequency, 115 pound-feet for on-off service, 32 pound-feet maximum for slip service, rated slip power 300 watts

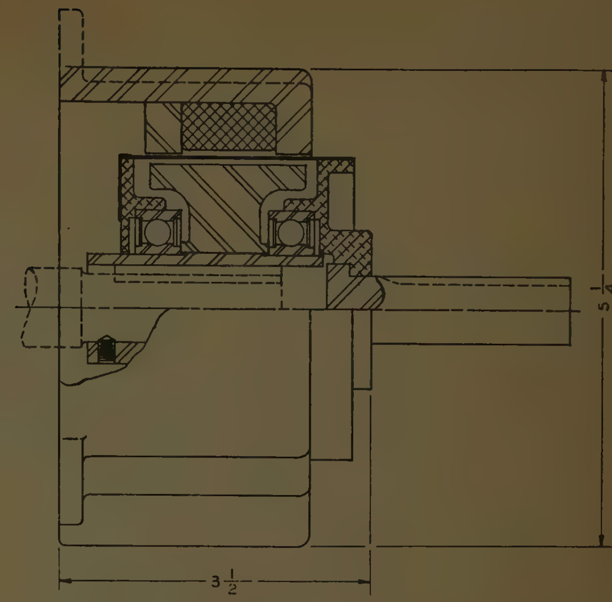


Figure 7. Magneclutch with stationary coil and saturable-bridge outer member, 10 pound-feet for on-off service, 2 pound-feet maximum for slip service, rated slip power 100 watts

well over 100 horsepower at 1,800 rpm.

It will be noted that Figure 3 shows two torque-versus-excitation characteristics. One is labeled "slip service" and the other "on-off." The difference is due to the use of a different magnetic medium for the two classes of service.

Although many of these clutches were originally developed for slip service, they will develop much greater rating when used for on-and-off applications. If, however, the starting duty is very frequent or if he load has very high inertia, the otal integrated amount of heat during the acceleration period must be aken into account when choosing the size of the clutch. Ratings are under consideration up to 1,000 horsepower and down to fractional and subfractional sizes for such applications as oil burner service.

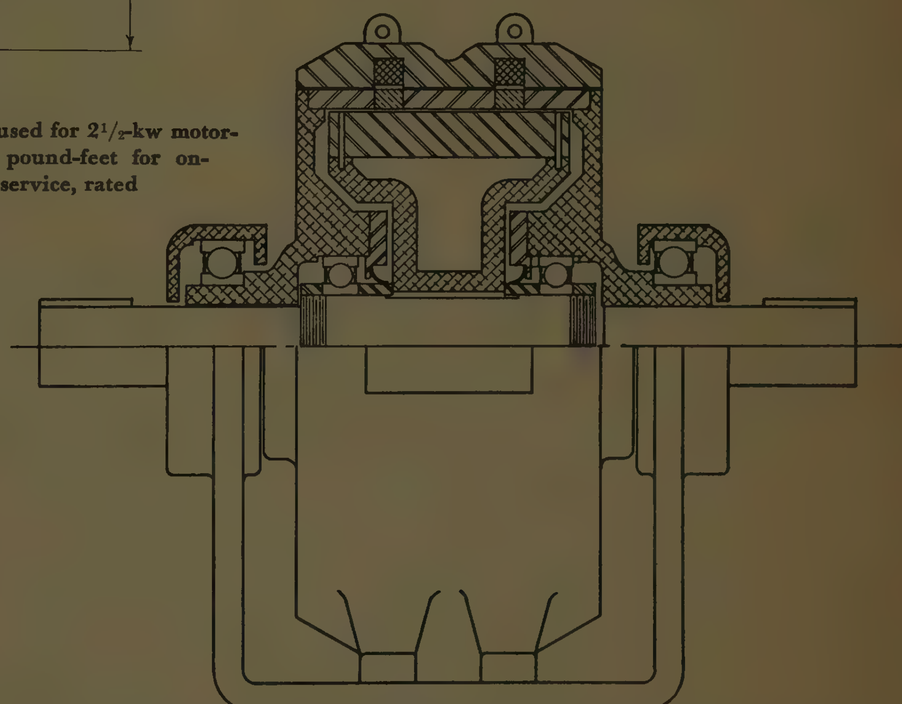


Figure 8. Illustrative cross section of 25-kw clutch, 450 pound-feet for on-off service, 115 pound-feet maximum for slip service, rated slip power 2,500 watts

It is expected that a wide market for such Magneclutches will be found in the variable-speed blower field since the horsepower required normally varies as the cube of the speed. The maximum amount of loss to be dissipated by the clutch would approximate only 15 per cent of the maximum power input. Reversing drives and clutch-brake combinations are in the process of development. These clutches have been found quite reliable and trouble-free when used as dynamometers in the laboratory. As far as can be determined at present there are no fundamental limitations with regard to size, speed, temperature, or life provided all of these factors are taken into account properly in the design.

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Out-of-Phase High-Voltage Switching

AN AIEE COMMITTEE REPORT

THE INITIAL OBJECTIVE of this AIEE Joint Subcommittee was to collect information on the frequency and severity of out-of-phase high-voltage switching operations and then to decide if further action was justified.

It was felt that the Committeemembers, through their business and committee affiliations, would be in a position to give a reasonably representative picture of high-voltage out-of-phase switching troubles; therefore, as a first step a questionnaire was sent out to the Committee members on June 15, 1948. It was hoped that sufficient material could be obtained this way and that the industry in general could be spared another questionnaire.

The replies indicated relatively few difficulties. General conditions considered were: out-of-phase closing, out-of-phase opening, and out-of-phase reclosing.

The total number of cases of out-of-phase switching actually reported are eight, four of them from one company, although it is known that more cases have occurred. In every case reported the circuit breaker cleared the fault even if it was damaged. Damage has been reported to interrupting-element parts and to a contact-bridging resistor. In most cases the damage has not been serious enough to prevent return to service.

The information received from the Committee members includes not only the experience within their own companies but also the knowledge gained from discussions with others and review of pertinent papers, such as "Power System Stability Requirements Determined by A-C Calculating Board Study, and Operating Performance Proved by Staged Fault Tests."[1] Therefore, it is felt that the survey represents a large proportion of the industry.

There is no doubt that high-voltage out-of-phase switching presents a definite problem, but the indications are that in many cases a solution has been found.

The only generally applicable remedy would be to use circuit breakers adequate and guaranteed to perform at twice normal voltage under all conditions. This would obviously increase circuit-breaker size and cost.

The impression gained from the survey is that the cost of the damage on the surveyed systems is much less than the cost of using circuit breakers adequate for twice normal voltage. It does not appear appropriate to have general circuit-breaker applications bear the burden of increased circuit-breaker size and cost, but there may be cases where the use of a higher voltage circuit breaker would be justified. An investigation of the type made by this Committee is obliged to consider the over-all picture, and there would be cases in disagreement with the general conclusion.

When the manufacturer sells a circuit breaker, the user receives not only a piece of equipment but guaranteed performance. Generally it is recognized that there is some margin of safety in performance; different for different circuit breakers and for different conditions. If it is necessary to utilize some or all of this margin it would obviously be the user's privilege and responsibility to do so. Because of the wide variety of circuit breakers and operating conditions, the manufacturers could not be expected to furnish generally applicable information but may be consulted in each individual case. Attention is called to the present trend to use circuit breakers with lower basic impulse insulation levels on effectively grounded systems, and the possibility that this method of reducing circuit-breaker costs may in some cases conflict with the desire to obtain a margin for out-of-phase switching.

Another promising method of attack is the judicious application of high-speed relaying, preferably in conjunction with 3- or 5-cycle circuit breakers. This means a complete investigation of each individual case and is very likely to give the desired results, but such investigations are outside the scope of this Committee.

Cases reporting the closing of a circuit breaker with the two sides out-of-phase indicate that more vigilance in operation and a closer check of synchronizing equipment would eliminate some of the problems.

System design and operating setup may be arranged to minimize the probability and effect of out-of-phase troubles. One system is built in such a manner that it can be automatically or manually separated at one point by a predetermined group of switching operations. A plug board is constantly arranged to trip any desired group of circuit breakers in the event of instability. By constantly supervising this board the load dispatcher can be sure that when a separation is made he will have as nearly as possible an equitable distribution of load and generation. The general trend in system growth and interconnections is gradually increasing system stability and reducing the causes of out-of-phase switching trouble.

A generally applicable solution cannot be justified economically on the basis of the information obtained by this Committee. Each individual case requires a thorough and special investigation to find the most satisfactory economical solution. This is beyond the scope of this Committee, but in addition to the general suggestions in this report the circuit-breaker manufacturers are urged to continue their efforts to find economically applicable means of increasing the chances of circuit breakers performing satisfactorily under abnormal system conditions.

Essentially full text of the final report of the AIEE Joint Subcommittee on "Out-of-Phase High-Voltage Switching." Members of the committee were: K. J. Falck, *Chairman;* R. M. Ferrill, G. D. Floyd, I. W. Gross, E. L. Harder, M. H. Hobbs, C. B. Kelley, Cort Lowerison, H. V. Nye, and B. W. Wyman.

REFERENCE

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Proposed Basic Impulse Insulation Levels For High-Voltage Systems

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Basic impulse insulation levels were established in 1941, and although many improvements have been added to systems since then, no changes have been made in the levels. This article summarizes the present knowledge of the factors on which these levels are based and recommends a new series of such levels.

SINCE THE establishment of basic impulse insulation levels (BIL's)[1] ere has been essentially no ange in the values up to e present time. There have en improvements in the ethod of operating system, creased knowledge of the ghtning discharges, and better understanding of the rge behavior of apparatus and its insulation. Several dustry committees are at present investigating the factors hich determine the BIL's. This article makes an evaluion of the essential factors upon which the selection BIL's can be based, and proposes a series of BIL's for loption by the industry based upon these considerations. nce the greatest need for a review in the industry at esent is associated with the transmission voltages 115 and above, this article is confined to the BIL's which ply to these circuit voltages.

THE FACTORS

THE PRINCIPAL factors to be evaluated in the establishment of BIL's are: nominal system voltage, system neual grounding, lightning-arrester rating and performance, htning-arrester location and system arrangement, imlse strength of equipment, and required margin.

Nominal System Voltage. The Joint Edison Electric stitute—National Electrical Manufacturers Association EI—NEMA) Report "Preferred Voltage Ratings for C Systems and Equipment,"[2] dated May 1949, gives e nominal and maximum tolerable zone voltages. The aximum voltage of the tolerable zone was used as a basis this study.

System Neutral Grounding. The AIEE Subcommittee on rounding Practices issued their third report in 1947, resent-Day Grounding Practice on Power Systems."[3] rt II of this report, which covered a total of 567 systems, ows that, of the companies reporting, nearly 100 per cent power systems 115 kv and above are operating with utrals grounded and that 95 per cent of these are effectively grounded according to the commonly accepted definition.[2,12] In Table XIX of the report it may be seen that for circuits rated 93 kv to 165 kv most systems have X_0/X_1 ratios less than three, although there are a few in which the ratio goes as high as four. Above 166 kv the systems have ratios ranging from zero to one. Of the effectively grounded systems having circuit voltages 93 kv and higher, only one had an R_0/X_1 ratio in excess of one, and that did not exceed a ratio of two. Since this is the practice, it is logical for standardization purposes to select lightning-arrester ratings based on grounded-neutral operation.

It may be necessary to use higher lightning-arrester ratings and insulation levels at nongrounded substations which may at times be separated from the grounded portion of the system.

Selection of Lightning-Arrester Rating. The report on grounding practices indicates that for circuit voltages of 115, 138, and 161 kv the systems are effectively grounded, and hence the rating of the lightning arrester can be 80 per cent of the line-to-line voltage. For these systems the voltage on the two unfaulted phases will not rise over the line-to-neutral voltage for the case of single line-to-ground faults by more than 40 per cent. While this rise in voltage may be lowered in some cases where lightning arresters are located at the transformers, it should be recognized that for lightning arresters located on the line side of a circuit breaker in the open position the conditions may require the full 80-per cent rating for the lightning arrester. There may also be cases for which the full 80-per cent lightning-arrester rating is required for transformers. Hence, the 80-per cent lightning-arrester ratings were chosen for this study.

For system voltages of 230 kv and up, however, the X_0/X_1 and R_0/X_1 ratios are generally less than for the 115 to 161 kv range, and the overvoltages on the unfaulted phases will not, except in unusual cases, exceed 30 per cent of the line-to-neutral voltage. Therefore, it appears logical to select lightning-arrester ratings for these higher circuit voltages which are 75 per cent of the line-to-line voltage. For circuit breakers at these higher voltages it probably will be necessary to use an 80-per cent lightning arrester, particularly on the line side, although the transformer lightning arrester in the same station can be a 75-per cent lightning arrester.

Table I gives lightning-arrester ratings which were

ential text of paper **50-152**, "Proposed Basic Impulse Insulation Levels for High-tage Systems," recommended by the AIEE Committee on Protective Devices and roved by the AIEE Technical Program Committee for presentation at the AIEE nmer and Pacific General Meeting, Pasadena, Calif., June 12–16, 1950. Scheduled publication in AIEE *Transactions*, volume 69, 1950.

. **Clem** is with the General Electric Company, Schenectady, N. Y.; **J. R. Meador** **W. J. Rudge** are with the General Electric Company, Pittsfield, Mass.; and H. **Powell** is with the General Electric Company, Philadelphia, Pa.

authors are grateful for the permission of the Consumers Power Company, Jackson, h., to use the heretofore unpublished data on lightning-arrester discharge currents uded in Figure 1; and for the assistance of S. B. Howard and several others for r suggestions and comments.

selected for the different systems. Even multiples of three kv were used as the minimum increment of rating.

Table I. Lightning-Arrester Ratings

		Lightning-Arrester Rating, Kv		
		Nongrounded Neutral	Grounded Neutral	
Preferred Nominal System Voltage, Kv	Maximum Tolerance Zone, Kv	100% Lightning Arrester	80% Lightning Arrester	75% Lightning Arrester
115	121	120	96	
138	145	144	117	
161	169	168	135	
230	242	240	192	180
288	302	300	240	228
345	360	360	288	270
360	378	378	303	282

Lightning-Arrester Performance Values and Tolerances. At the request of AIEE Standards Co-ordinating Committee 8 (Insulation Co-ordination), the lightning-arrester manufacturers reviewed their production records to determine if it would be feasible to reduce the maximum tolerance of lightning-arrester performance as given in the report, "Performance Characteristics of Lightning Protective Devices."[4] The NEMA Lightning Protective Devices Committee, after reviewing the matter, replied that a review of the present-day manufacturing practice and performance values for station- and line-type lightning arresters has shown that the plus tolerances relating to impulse sparkover and discharge voltage drop in the resistance can be reduced by 5 per cent, see Table II.

Table II. Reduction of Tolerances

Type of Lightning Arrester		New Tolerances, Per Cent	Present Tolerances,[4] Per Cent
Station:	Impulse Sparkover	15	20
	Discharge Voltage	20	15
Line:	Impulse Sparkover	20	25
	Discharge Voltage	15	20

Note: These tolerances may also apply to the current wave later discussed in this article.

In addition to the tolerances shown in Table II, the committee pointed out that approximately 95 per cent of the lightning arresters supplied have performance values which do not exceed the average plus two-thirds of the stated maximum tolerance. The NEMA Committee recommended that the protective level of the lightnir arrester be taken as a value which is the average value pl two-thirds of the stated maximum tolerance.

Discharge Currents in Service. A review of the data o tained in several separate investigations[5–8] of discharg currents through lightning arresters in stations resulted i the average discharge expectancy curve shown in Figure For the study reported in this paper a crest value of 5,0 amperes was chosen as a reasonable reference base. will be noted that a discharge current exceeding this valu will occur only once in about 70 lightning-arrester years.

A further review of the data from three separate invest gations[6,7,9] giving the time to crest for currents discharge through lightning arresters in stations resulted in th average expectancy curve, Figure 2. The data did n show any direct or definite correlation to exist betwee the time to crest or rate of rise and the crest curren although it was noted that many of the fast rates of ri occurred with low crest values of current. The highe recorded rate of rise is approximately 5,000 amperes p microsecond[10] (10 per cent and 90 per cent points), and wa associated with a crest current of 7,900 amperes. Th data was obtained on a 23-kv system which had no ground wire shielding. It appears reasonable from the revie of these data to use as the basis for this study a rate of ris of 5,000 amperes per microsecond, and to associate wit this a crest value of 5,000 amperes. This gives a wav having an effective front of 1.0 microsecond, based o measurements of the time between the points of 10 and 9 per cent of crest value.

This choice of 5,000 amperes and 5,000 amperes p microsecond presumes that the overhead line leading in the station, and the station itself, will be protected by ove head ground wires. The ground wires should extend fo a distance of about one-half mile from the station steel.

If it is assumed that the time to crest is 1.2 times the tim of the effective front, it may be seen from Figure 2 that time to crest of 1.2 microseconds, or an effective front of o microsecond, occurs once in five lightning-arrester year

Separation Between Lightning Arrester and Transformer. Th difference in the voltage at a transformer, or other pr tected equipment, from the voltage at the lightning a rester, when there is some circu distance between them, has been i vestigated in several studies.[11] Th relation between the lightning-a rester protective levels and pr posed BIL's is based on using a connection, as defined in referen 11, and limiting the separation b tween the lightning arrester an protected equipment. The circu distance, or separation, between t lightning arrester and the protect equipment may cause an oscillato increase in the voltage at the pr tected equipment above the ligh ning-arrester discharge voltag The limiting separations given la

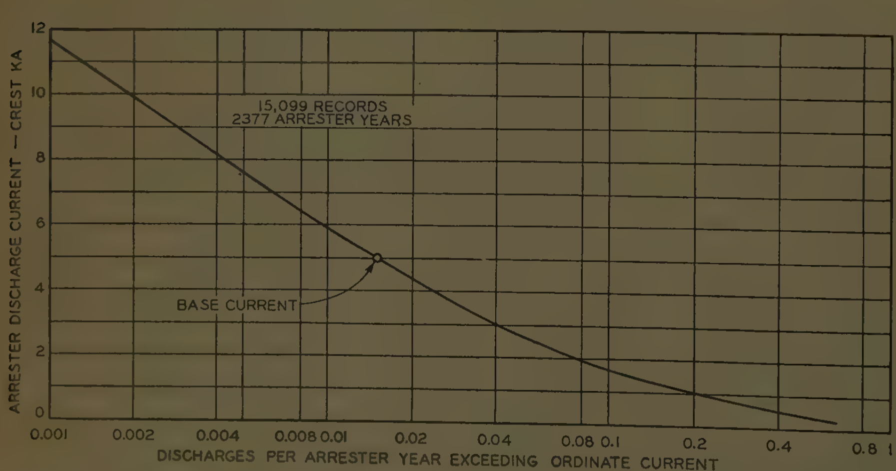


Figure 1. Discharge currents measured through lightning arresters in stations[5,6,8]

e chosen so that the crest value of e first cycle of the oscillatory voltge at the protected equipment does ot exceed the lightning-arrester discharge voltage by more than 30 per ent. These limiting separations are onsidered representative of singlene stations because the analysis pon which they are based condered only an elementary circuit onfiguration and did not include e effect of a bus or additional inoming lines.

Impulse Strength of Equipment. The merican Standards Association ASA) impulse test on high-voltage ansformers consists of a 1.5x40 ll wave at BIL value and two aves at a level which is 15 per cent gher and chopped in not less than 3.0 microseconds. A front-of-wave test is sometimes made to demonstrate e volt-time turn-up of the transformer insulation. Test sults previously presented[13] before the AIEE show that e impulse puncture strength of the major insulation used transformers is constant from about 3.0 microseconds several hundred microseconds or more. For shorter mes the impulse strength increases. At 0.5 microsecond e breakdown is about 50 per cent greater than 3.0 microconds. This volt-time relationship, which has been sed to determine the front-of-wave test in the NEMA ransformer Standards, is shown as Curve 1 in Figure 3.

Other parts of the transformer, such as oil spacings, eepage paths, and so forth, have other volt-time curves. owever, the minimum envelope of these curves tends to llow a volt-time curve similar to Curve 2 in Figure 3. hus, the over-all transformer volt-time curve can be presented best by a composite broken curve going from 5 microsecond to 3.0 microseconds along Curve 1, and om 3.0 microseconds to longer times along Curve 2. The otted points represent the ASA full-wave and choppedave tests. The exact point along Curve 1 for showing e NEMA front-of-wave test depends on the insulation st level of the transformer, since this test is made with a ltage rising at approximately 1,000 kv per microsecond. ll transformers designed to meet the ASA impulse tests e designed also for this front-of-wave test.

The impulse insulation strength of switchgear is usually ecked, when required, by full-wave impulse withstand sts at BIL value. During the design and development power circuit breakers, chopped-wave tests also are ade. These tests are made at values 35 to 50 per cent ove the full-wave withstand values. However, as switchar equipment contains no windings, the magnitude of e test voltage is of more importance than the rate of ange of the voltage wave.

Effect of Oscillations on Transformer Insulation. Since the rcuit separation between the lightning arrester and the ansformer results in a high-frequency oscillation being perimposed upon the voltage wave which appears at e transformer terminals, it is necessary to determine the

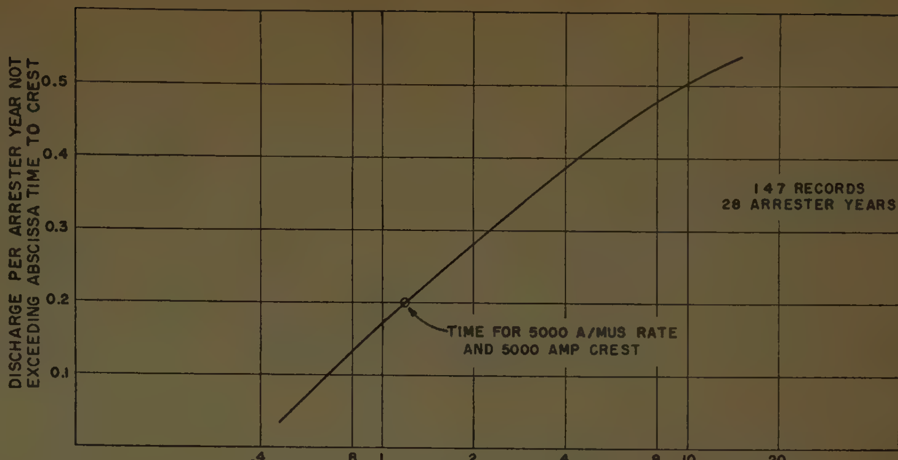


Figure 2. Time-to-crest value of discharge currents measured through lightning arresters in stations[6,7,9]

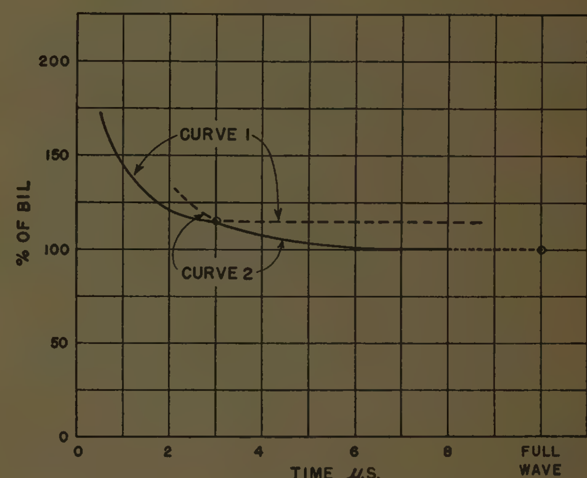


Figure 3. Transformer volt-time curves

effect such a voltage would have on the transformer insulation. Since the superimposed oscillations are of very short duration, relative to the 1.5x40 microsecond test wave, it is apparent from Figure 3 that the Curve 1 portion of the transformer volt-time curve will be most affected by them. A few spot tests have indicated that insulations of the type represented by Curve 2 are not appreciably affected by them.

To get an estimate of the effect of these oscillations on transformer insulation, samples having a volt-time curve similar to Curve 1, Figure 3, were selected for these tests. These samples consisted of heavily insulated conductors taped together and immersed in oil. When tested with smooth 1.5x40 waves a curve very similar to Curve 1, Figure 3, was obtained.

Similar samples were tested with 1.5x40 (negative polarity) waves having damped superimposed high-frequency oscillations. There were three variables in addition to the magnitude of the 1.5x40 wave: (1) period of oscillation; (2) degree of damping; and (3) per cent overshoot of the oscillation. The test results are shown in Figure 4. The points are plotted to show how much, for equal severity on the insulation, the magnitude of the smooth 1.5x40 wave upon which the oscillations are super-

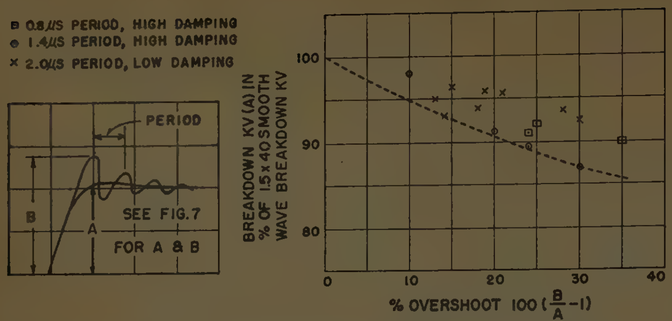


Figure 4. Effect of superimposed oscillations on strength of insulation samples

imposed must be reduced as the magnitude of the superimposed oscillation (overshoot) is increased. On the assumption that these insulation samples are reasonably representative of transformer major insulation, a significant conclusion can be drawn.

From Figure 3 it is apparent that transformer major insulation puncture strength will withstand a full wave at the chopped-wave level. The problem, then, is to determine what oscillations can be superimposed on the full wave at the BIL value to have the same destructive effect as a smooth full wave at the chopped-wave level. On Figure 4, to be conservative, the curve is drawn through the minimum points. This curve goes through 87-per cent magnitude for a wave having 30-per cent overshoot. The conclusion is that a damped high-frequency oscillation,

Table III. Maximum Permissible Separation

Lightning-Arrester Rating, Kv rms	Number of 12-Kv Units	Maximum Separation, Feet
96	8.0	9
117	9.75	15
135	11.25	20
180	15.0	38
228	19.0	72

whose first crest is 30 per cent above the smooth wave, may be superimposed on the full wave without stressing the transformer major insulation to a greater extent than the ASA chopped wave, since the ASA full-wave test is 87 per cent of the chopped-wave test. For this reason the permissible separation between lightning arrester and transformer used in this selection of BIL's was so chosen that the oscillation superimposed on the lightning-arrester voltage was limited to 30 per cent and would, therefore, not require the addition of any insulation to take care of it. Table III gives the maximum separation which is permissible on this basis for the lightning-arrester ratings proposed. The method of arriving at these distances is given in reference 11, and the distances are based on the elementary circuit configuration.

Ratio of Single to Multishot Strength of Transformer. It is necessary to evaluate the long-time strength of transformers that are periodically subjected to transient voltages. Some of the factors which must be considered are:

1. Laboratory investigations of the effect of repeated applications of impulse voltages are compressed into a short period of time. A transformer in service may b subjected to only one or two high impulse voltages in on year and have long intervals to recover. Therefore, th ratios of single-to-multishot strength determined fron laboratory test results are probably not directly indicativ of the multishot strength of the transformers in service.

2. During factory impulse testing, transformers some times are subjected to many times the required number o impulse voltages, and it is extremely rare for these addi tional applications of voltage to cause failure.

3. If a transformer being tested is near breakdown, thi condition is often detectable by modern, testing technique

These factors tend to deprecate the need for additiona margin to allow for repeated application of voltage i service. However, a strong argument can be made fo a multishot allowance. Since it is a known fact that som transformers fail as a result of a single impulse during th factory test, it cannot be said that the units which do no fail have an additional margin of strength to enable ther to withstand a large number of impulses. Therefore it i unreasonable to expect that all transformers passing th factory test have multishot strength. For this reason som margin is necessary between the protective level and th demonstrated strength of the transformer.

REQUIRED IMPULSE INSULATION LEVELS

Lightning-Arrester Discharge Voltage. Since the publishe data on lightning-arrester performance are given on th basis of a 10x20 microsecond wave, it is necessary to use correction factor to derive the lightning-arrester discharg voltage for a different wave shape. This point was brough up for discussion at the meeting of an AIEE Subcommitte of the Protective Devices Committee, and the manufac turers stated that the crest value of discharge voltage for 5,000-ampere 5,000-ampere-per-microsecond discharge cu rent is approximately the same as the crest value of th discharge voltage for a 10,000-ampere 10x20 discharg current. On this basis the lightning-arrester discharg voltage, or protective level, for station-type lightning a resters of representative voltage ratings, on the basis of 5,000-ampere discharge current, is as shown in Table IV

Table IV. Station-Type Lightning Arresters

Lightning-Arrester Voltage Rating, Kv	Lightning-Arrester Discharge Voltage Protective Level, Kv	
	10x20-Microsecond Wave	5,000-Amper Per Microseco
12	43	47
96	345	373
120	430	467
240	860	931

Discharge voltages are for a current discharge having crest value of 5,000 amperes. These values are shown Curve *A*, Figure 5.

By using the method contained in ASA Standar *Z1.1*, *Z1.2*, and *Z1.3* it can be shown that as lightnin arrester units are stacked in series the effective plus toleran for the entire stack is decreased with the number of un in the stack. It is proportional to the number of units series, so that the plus tolerance for four units is half th for one unit.

equired Margin. When choosing the margins the follow- factors should be considered:

. The deviations in lightning-arrester performance.
. Effect of separation between lightning arrester and tected equipment.
. The single and multishot strength of equipment.
. Possible occurrence of impulse currents above 5,000 peres and 5,000 amperes per microsecond.

The lightning-arrester manufacturers have made allow-e for the deviations in lightning-arrester discharge tages in recommending a protective level to be deter-ned by adding a factor of two-thirds the plus tolerance to average performance values. Therefore, it is felt t no additional margin is required for this factor.

The superimposed oscillation in the voltage across the ipment being protected causes an increase in voltage ove the protected level maintained by the lightning ester. By imposing limits on the separation between lightning arrester and the protected equipment this tor is adequately taken care of.

The transformer strength is demonstrated by two applica-ns of a chopped-wave test, but sometimes several applica-ns of the test are made before the test is completed. e transformer insulation strength may deteriorate in vice due to the application of several high-voltage pulses. It is reasonable to provide some margin for se contingencies.

The probability of discharge currents through the tning arrester exceeding 5,000 amperes should also be luded in the margin.

It is not good engineering to pyramid the separate ety margins for each of the foregoing factors. Con-ering all of them together, it seems reasonable to use an over-all margin of 20 per cent above the protective level provided by the lightning arrester to establish the minimum required impulse insulation levels.

Curves *C* and *D* in Figure 5 were plotted at 20 per cent above the lightning-arrester discharge voltage shown by Curves *A* and *B*, respectively. Curve *D* evaluates the stacking factor and represents the minimum required impulse insulation levels obtained from this analysis.

Table V gives the required impulse insulation levels for systems with nominal system voltages of 115 to 360 kv, using the lightning-arrester ratings from Table I.

Table V. Required Impulse Insulation Levels

Nominal Circuit Voltage, Kv	Impulse Insulation Level: Isolated Neutral	Grounded 80% Lightning Arrester	Neutral 75% Lightning Arrester	Present BIL's, Kv
115	540,562*	432,450*		550
138	645,675*	518,542*		650
161	750,788*	605,630*		750
230			810,850*	1,050
288			1025,1062*	1,300
360			1268,1331*	(1,615)

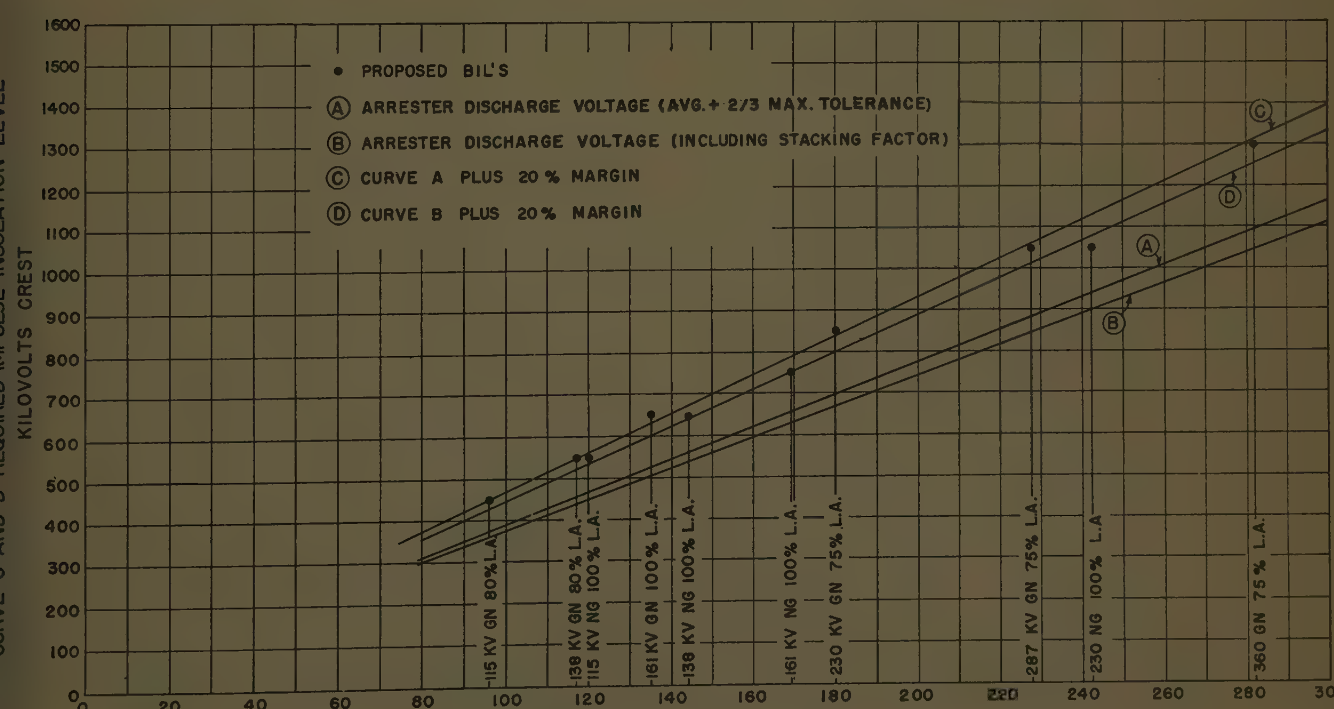
* The minimum value for the required impulse insulation level represents that which could be used if the lightning arrester was given full credit for the stacking factor. The larger value is obtained when the stacking factor is ignored completely.

During the preparation of Table V, the following facts were brought out:

1. There are no preferred system voltages above 230 kv. However, there is a system already operating in this country at 288 kv (sometimes listed as 287.5 kv).

2. The system voltage of 360 kv is listed instead of 345 kv as in the BIL report[1] because it is the highest system voltage that can use the present standard BIL of 1,300 when operated as an effectively grounded system.

3. The standard BIL for the listed 345-kv reference



igure 5. Lightning-arrester discharge voltage and required insulation level versus lightning-arrester rating in rms kilovolts

class is 1,550, and the value of 1,615 given for the 360-kv nominal system voltage is consistent with present of BIL's.

SELECTION OF BIL'S

The Effect on Transformer Design. It should be realized that the strength of insulation is not predictable to within two or three per cent. Turn insulation, spacings between coils, the thickness and number of insulating barriers, and so forth, cannot be changed in extremely small increments. These components become standardized building blocks for the designer to use for a given BIL value.

This standardization of the components used to secure a given BIL has contributed greatly to transformer reliability and lower cost by permitting repetitive use of certain insulation structures. It would require a long time and involve considerable expense to gain back the loss entailed in changing to new insulation levels or BIL's which are only slightly different from those now in use.

Requirements for Ungrounded Installations. There may be occasions when transformers and circuit breakers supplied on systems of 115 kv, 138 kv, and 161 kv may be called upon to operate on ungrounded neutral circuits. Accordingly, it is desirable to have levels suitable both for grounded-neutral system operation and also for isolated-neutral operation for these circuit voltages. This requirement probably will not exist for system voltages 230 kv and higher.

Insulation Levels for Switchgear: Circuit Breakers. Power circuit breakers present different problems than do transformers when the problem of reducing insulation is considered, because the voltages at their terminals are not always subject to the same degree of control as those at transformer terminals.

It has been pointed out that most systems operating at voltages of 230 kv and higher are operated with their neutrals very well grounded. Circuit breakers with reduced insulation levels have been used successfully on these systems for a number of years. However, it is desirable to give further study to these systems.

Systems operating at 115, 138, and 161 kv are discussed as a group, since they present additional special problems. It is noted that a large per cent of these systems are at times operated ungrounded, or so that the X_0/X_1 ratios are greater than 3.0. Loss of ground also may occur on the opening of some of the line circuit breakers. Thus a grounded-neutral rated lightning arrester could not, in these cases, be used to protect circuit breakers used on systems operating at 115, 138, and 161 kv.

Insulation Levels for Switchgear: External Porcelain Insulation. The life of bushings and insulators which are used with circuit breakers, switches, bus supports, and so forth, probably will not be reduced by operating them at higher 60-cycle voltages than at present. Such a condition would result if the low-frequency wet and dry withstand tests were reduced in the same proportion as the reduction in impulse levels. However, creepage and strike distances over the exposed surface must be reviewed very carefully before reducing the size of these parts.

Air switches are designed with open gap distances which are at least 10 per cent greater than the insulator striking distance. A reduction in insulation could be reflected in reduced switch dimensions. However, the material savings would be small, and problems involving corona and radio noise would be amplified. Smaller open break distances also reduce the isolating safety factor of the switch.

It is questionable if any reductions in the size of the external porcelain insulating part of equipment used on circuits operating at 115, 138, and 161 kv can be justified, even with effectively grounded neutrals.

THE PROPOSAL

BASED on the foregoing considerations and analysis, the authors propose that values shown in Table VI be adopted as basic impulse insulation levels for equipment used on systems operating at nominal voltages of 115 kv and higher. These values are on the basis of the standard 1.5x40-microsecond impulse voltage wave. They have been determined on the basis that the circuit distance between the lightning arrester and the protected equipment will not exceed the maximum values shown in Table III.

Table VI. Proposed Basic Impulse Insulation Levels

Nominal System Voltage, Kv	Isolated Neutral Circuit, BIL Kv	Grounded Neutral Circuit, BIL Kv
115	550	450*
138	650	550*
161	750	650*
230		†850**
288		1,050**
360		1,300**

Values in the second column are to be used for switchgear, and for transformers if and when necessary.
* Values are to be used for transformers, not for switchgear.
** Values are to be used for both switchgear and transformers.
† A lower value of 825 could be reasonably derived from this analysis by giving partial credit for the benefit of the stacking factor.

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Motionally Induced Electromotive Force—Part III

Iotional Electromotive Force in a Vacuum

Jack, the physicist, is continuing his lectures to Alter go and his friends on the basic principles underlying ectric motors and generators.

Jack: "I am sorry that this subject of the Hall Effect me up (*EE, Dec '50, pp 1086–87*). I guess now that I'll st have to tell you that we may regard it as well established experiment and experience that there is a motional ectric field $\mathbf{E}_{mot}$ induced in any body which moves in a agnetic field $\mathbf{B}$, and $\mathbf{E}_{mot}$ is given by the equation

$$_{mot}=\frac{1}{c}[\mathbf{v} \times \mathbf{B}] \qquad (1)$$

this equation, $\mathbf{v}$ is the ordinary everyday velocity of the aterial of the body and has no reference to the motion of ectrons or any other theoretically existing microscopic rts of the body. $\mathbf{E}_{mot}$ acts on the body just like any her electric field such as $\mathbf{E}_s$, the electrostatic field pro-iced by charges, and $\mathbf{E}_{ind}$, the electric field produced by agnetic fluxes varying in time, or in other words, by ansformer action. The current density in the body, if satisfies Ohm's Law, will be given by

$$=\sigma(\mathbf{E}_s+\mathbf{E}_{ind}+\mathbf{E}_{mot}) \qquad (2)$$

"I now come to an interesting relation. Integrate $+\mathbf{E}_{ind}+\mathbf{E}_{mot}$ around a closed path which goes through e material bodies and which is being carried along with e matter in the bodies. For $\mathbf{E}_{ind}$ we have of course

$$\int \mathbf{E}_{ind}\cdot ds = -\int\int \frac{1}{c}\frac{\partial \mathbf{B}}{\partial t}\cdot d\mathbf{S} \qquad (3)$$

here on the right we have the rate of change of the normal mponent of $\mathbf{B}$, integrated over any surface which is omentarily bounded by the moving curve of integration.

"For $\mathbf{E}_{mot}$ we have from equation 1

$$\int \mathbf{E}_{mot}\cdot d\mathbf{S} = \int \frac{1}{c}[\mathbf{v} \times \mathbf{B}]\cdot ds = -\int \frac{1}{c}\mathbf{B}\cdot[\mathbf{v} \times ds] \qquad (4)$$

ut $[\mathbf{v} \times ds]$ is the rate of increase of the area bounded by e closed curve due to the motion of the element ds. herefore, $\int \mathbf{B}\cdot[\mathbf{v} \times ds]$ of equation 4 is that rate of increase $\int\int \mathbf{B}\cdot d\mathbf{S}$ taken over the bounded surface, which arises om the motion of the bounding curve itself. Now re-embering that $\int \mathbf{E}_s\cdot ds=0$, we have, combining with uations 3 and 4 for the total field, $\mathbf{E}_{tot}$, acting on the aterial of the moving bodies, and producing effects like rrent flow, or dielectric polarization

$$\int \mathbf{E}_{tot}\cdot ds=\int(\mathbf{E}_s+\mathbf{E}_{ind}+\mathbf{E}_{mot})\cdot ds = -\int\int\frac{1}{c}\frac{\partial \mathbf{B}}{\partial t}\cdot d\mathbf{S} - \int \frac{1}{c}[\mathbf{v} \times \mathbf{B}]\cdot ds \qquad (5)$$

ut the right-hand side of equation 5 reduces to $-1/c$ times the total rate of increase in $\int\int \mathbf{B}\cdot d\mathbf{S}$, that due to rate of change of $\mathbf{B}$ itself, that is to $\partial\mathbf{B}/\partial t$, and that due to the motion of the boundary curve. Thus we have

$$\int \mathbf{E}_{tot}\cdot ds = -\frac{1}{c}\frac{d}{dt}\int\int \mathbf{B}\cdot d\mathbf{S} \qquad (6)$$

where the plain d/dt means the total rate of change of the flux linkage of the circuit, $\int\int \mathbf{B}\cdot d\mathbf{S}$, including the effect of the motion of the bounding curve itself.

"This is Faraday's Law of Induction for moving bodies which says that the total electromotive force around a circuit, or $\int \mathbf{E}_{tot}\cdot ds$, is equal to $-1/c$ times the rate of change of the flux linkage regardless of whether that electromotive force is due to motion or to transformer action. Faraday found that he got the same currents induced in a coil

$$I=\frac{1}{R}\int \mathbf{E}_{tot}\cdot ds \qquad (7)$$

regardless of whether he moved a magnet relative to the coil, or the coil relative to the magnet.

"But now I am not at all surprised to see that Alter Ego has been trying to ask some questions."

Alter Ego: "You say now that the motional electric field $\mathbf{E}_{mot}$ is the same for all bodies regardless of their internal constitution and is given by equation 1. If I use a glass rod as a slide bar in the slide wire experiment, will I get this motionally induced field in it which will induce an electric induction $\mathbf{D}$ in it like a purely electrostatic field of the same magnitude?"

Jack: "Well, if I hadn't learned my lesson from our discussion of the Hall Effect I would have said no, because I know that in the case of the electrostatic field any one dipole is not in the field which is impressed upon the glass, since the neighboring dipoles cause the field to be different at the one dipole. Actually the field at this dipole is $\mathbf{E}_s+\frac{4\pi}{3}\mathbf{P}=\frac{\epsilon+2}{3}\mathbf{E}_s$, where $\mathbf{P}$ is the polarization density of the material. This is known as the Mossotti effect. However, for the motional field, $(1/c)[\mathbf{v} \times \mathbf{B}]$, $\mathbf{B}$ will not be shielded or modified by the adjacent dipoles so I would have supposed that the motional field, $\mathbf{E}_{mot}$, would produce a different effect than a purely electrostatic field $\mathbf{E}_s$. However, I'll stick to my general principle and say that the motional field $\mathbf{E}_{mot}=(1/c)[\mathbf{v} \times \mathbf{B}]$ will produce exactly the same effect as an electrostatic field $\mathbf{E}_s$."

Alter Ego: "Then since an electrostatic field $\mathbf{E}_s$ acting on the stationary glass rod would produce an induction $\mathbf{D}$ given by

$$\mathbf{D}=\epsilon\mathbf{E}_s \qquad (8)$$

for the glass rod moving in the magnetic field we should have

$$\mathbf{D}=\epsilon\frac{1}{c}[\mathbf{v} \times \mathbf{B}] \qquad (9)$$

shouldn't we?"

Jack: "Yes, but of course there will be end effects which will produce an electrostatic field $\mathbf{E}_s$ which will partly oppose $\mathbf{E}_{mot}$ so that we will have

$$\mathbf{D}=\epsilon\left(\mathbf{E}_s+\frac{1}{c}[\mathbf{v}\times\mathbf{B}]\right) \tag{10}$$

Alter Ego: "I can get rid of the end effects by using a dielectric ring which can stretch, like rubber, so the motion of the material will be radial as I change the radius of the ring. I'll still have a motional field $\mathbf{E}_{mot}=(1/c)[\mathbf{v}\times\mathbf{B}]$ acting circumferentially in the ring?"

Jack: "Why, yes."

Alter Ego: "Suppose this ring is an insulating tube, like an inner tube, with air in it. As the ring stretches, the air in it will also move with a radial velocity $\mathbf{v}$, so in the air, too, according to your equation 1 there will be a circumferential motional field, $\mathbf{E}_s=(1/c)[\mathbf{v}\times\mathbf{B}]$."

Jack: "I must say that would be true. My equation 1 is universal."

Alter Ego: "Now suppose the tube material can stretch but is sufficiently rigid so that I can pump the air out. Since your equation 1 does not have in it the pressure or density of the material which is moving, $\mathbf{E}_{mot}$ will not be affected by my pumping. When I get down to a vacuum then, I'll still have the full $\mathbf{E}_{mot}=(1/c)[\mathbf{v}\times\mathbf{B}]$ in it?"

Jack: "Well, somehow I do not like your conclusion that there will be a motional field in a vacuum. I am not sure that you can say that the vacuum has a velocity $\mathbf{v}$, although I must admit it moves along with the tube. You have me stumped, Alter Ego. I do not know whether there will or will not be a motional field $\mathbf{E}_{mot}$ in the vacuum. I am sure that equation 1 holds for all honest-to-goodness matter. But, how low the density has to be for matter to stop being honest-to-goodness matter for which equation 1 always holds, I do not know."

Well, Jack is to be commended for his honesty and frankness. Can the reader clear up the difficulty in this discussion? Can there be a motionally induced electric field in a vacuum?

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Reactive Power

A simple linear 2-terminal network can be designed so that its vector impedance to currents of third harmonic frequency will be the conjugate of its vector impedance to currents of fundamental frequency. When a voltage wave containing a third harmonic is impressed on the network,

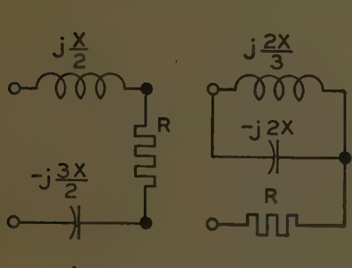

Figure 1. Networks whose impedances to third harmonics are the conjugates of their impedances to fundamental currents

the following quantities can be measured: (1) the rr voltages across the terminals and across any element the network (E, E_C, E_L, E_R); (2) the rms current in ar element of the network (I, I_C, I_L, I_R); (3) the real or acti power input to the network in watts (P). It is a simp matter to demonstrate that the power factor of a netwo shown in Figure 1 is independent of the magnitude of th third harmonic.

$$\lambda=\frac{P}{EI}=\frac{E_R}{E}=\frac{R}{Z}$$

This power factor is the per-unit value of active pow on a volt-ampere base equal to the apparent power of th network. (Positive sign is assigned to reactive power the current leads the potential difference. This corr sponds to the convention adopted in 1935 by the Inte national Electrotechnical Commission, although an AIE Committee has recommended the opposite convention). Can the magnitude and the sign of the per-unit reacti power (reactive factor) for the networks of Figure 1 l determined from the electrical measurements made c the circuit?

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Star or Delta?

The reader is confronted with two identical boxes perfectly conducting material which contain networks pure electrical constants. One box contains an inductan L and two resistors R ohm-connected in star; the oth box contains two inductive impedances having R oh resistance and $2L$ inductance in series and a condenser

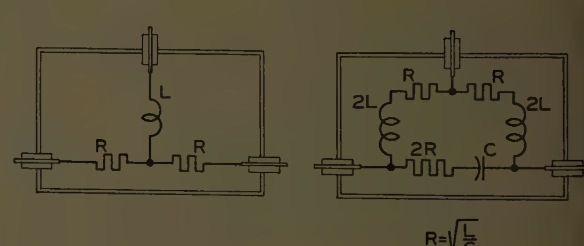

Figure 1. Identical boxes containing networks consisting of pu electrical constants

in series with $2R$ ohm resistance, the three connected delta as shown in Figure 1. The resistances, inductanc and capacitances in the networks are related by the e pression $R=\sqrt{L/C}$. By purely electrical measureme at the box terminals, determine which box contains t star-connected network.

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Motionally Induced Electromotive - Force—Part II. The
lowing is the author's answer to his previously published
ay (*EE, Dec '50, pp 1086–87*).

"O, what a tangled web we weave,
When first we practice to deceive."

Question 1. Poor Jack! He should not have appealed
electron theory at all. He knew that the simple Lorentz
ctron theory picture of matter is not true, but it had the
eat merit of being understandable to his students, Alter
o, and his friends. How many teachers face this
emma! To give a false theory, which the students
ll say they understand, or a more sophisticated and truer
tement which will be incomprehensible to the immature
dent?

Questions 2 and 3. No, Jack did not present the simple
rentz picture correctly, and yes, there is a more general
croscopic principle that Jack might have appealed to,
d then he could have left the electrons out. In fact,
ck tacitly used this general principle in his faulty treat-
ent of the Lorentz theory, although of course that is not
at made his treatment faulty.

Now what Jack is after, of course, is the constitutive rela-
n for a metal in motion, assuming that for a metal at rest
s

$$\sigma\mathbf{E} \tag{1}$$

w, Jack did assume in his discussion that in some sense
moving bar had exactly the same properties as the
tionary bar, and that relative to the electrons inside it,
relative to any other objects moving along with it, the
r would behave the same as the bar at rest, relative to
electrons within it, or relative to other objects at rest
th it. But this is the principle of relativity, and Jack
l not need to go farther to derive the constitutive
uation for the moving bar. Knowing the constitutive
uation for the bar at rest, say Ohm's law, or equation 1,
en relativity alone is sufficient to determine the constitu-
e equation for the bar in motion, and further inquiry
o the details of microscopic electron theory is unnecessary,
d for the desired purpose, irrelevant.

If we include among the objects moving along with the
ving bar an observer, B, then the principle of relativity
t described would assert that to the observer B the bar
uld appear, through such experiments as B could make,
have the same constitutive equation as that for the bar
rest, as determined by an observer A, also at rest with
bar.

Therefore, if B sees the field $\mathbf{E}'$, and the current $\mathbf{i}'$, B
l find the constitutive equation

$$\sigma\mathbf{E}' \tag{2}$$

But the fields $\mathbf{E}'$, and so forth, and the charge and
rent densities ρ', $\mathbf{i}'$, which B sees will not be the same as
fields $\mathbf{E}$, and so forth, and the charge and current
sities, ρ, $\mathbf{i}$, which A sees, since B and A will differ as to
at is the velocity of the charged probes which they use
observing the fields. If A and B use relativistic particle
mechanics, the field $\mathbf{E}'$ will be related to the fields $\mathbf{E}$ and
$\mathbf{B}$ by the equations

$$\mathbf{E}_x'=\mathbf{E}_x$$

$$\mathbf{E}_y'=\left(\mathbf{E}_y-\frac{1}{c}v\mathbf{B}_z\right)\left(1-\frac{v^2}{c^2}\right)^{-1/2}$$

$$\mathbf{E}_z'=\left(\mathbf{E}+\frac{1}{c}v\mathbf{B}_y\right)\left(1-\frac{v^2}{c^2}\right)^{-1/2} \tag{3}$$

where the velocity $\mathbf{v}$ is entirely in the x direction, and is of
magnitude v.[1] If we neglect v^2/c^2 compared to 1, then
equation 3 reduces to

$$\mathbf{E}'=\mathbf{E}+\frac{1}{c}[\mathbf{v}\times\mathbf{B}] \tag{4}$$

which is also what we would get if we used Newtonian
particle mechanics.

Similarly, if we used relativistic particle mechanics and
neglect v^2/c^2 compared to 1, we get

$$\mathbf{B}'=\mathbf{B}-\frac{1}{c}[\mathbf{v}\times\mathbf{E}] \tag{5}$$

If we had used Newtonian particle mechanics, with the
definition we have given for $\mathbf{B}$, we would have had

$$\mathbf{B}'=\mathbf{B} \tag{5A}$$

However, equation 5 with the other related primed vectors
satisfies Maxwell's equations except for terms involving
v^2/c^2, whereas equation 5A would fail to satisfy Maxwell's
equations by terms involving v/c.

Similarly for the other field quantities, neglecting
v^2/c^2 compared to 1, we have

$$\mathbf{H}'=\mathbf{H}-\frac{1}{c}[\mathbf{v}\times\mathbf{D}] \tag{6}$$

$$\mathbf{D}'=\mathbf{D}+\frac{1}{c}[\mathbf{v}\times\mathbf{H}] \tag{7}$$

$$\mathbf{i}'=\mathbf{i}-\frac{1}{c}\rho\mathbf{v} \tag{8}$$

$$\rho'=\rho+\frac{1}{c}\mathbf{v}\cdot\mathbf{i} \tag{9}$$

Equations 8 and 9 may seem strange, suggesting that
relatively moving observers will disagree as to the charge
and current densities in a given body, but they are true,
(except for higher powers of v/c) and to be expected, as
will be developed in later essays.

Now if observer B finds Ohm's Law or equation 2
holding for the metal body at rest relative to him, then
observer A will find for that same body moving with
velocity $\mathbf{v}$ relative to him

$$\mathbf{i}-\frac{1}{c}\rho\mathbf{v}=\sigma\left(\mathbf{E}+\frac{1}{c}[\mathbf{v}\times\mathbf{B}]\right) \tag{10}$$

obtained by substituting equations 4 and 8 in equation 2.

Observer B may also find that the charge density ρ' in
a homogeneous metallic body at rest relative to him is
always zero. If we set $\rho'=0$ in equation 9, then, except
for higher powers of v/c, equation 10 will reduce to

$$\mathbf{i}=\sigma\left(\mathbf{E}+\frac{1}{c}[\mathbf{v}\times\mathbf{B}]\right) \tag{11}$$

Thus, we get equation 11 which is basic for the usual treatment of voltages induced in moving wire coils as given in electrical engineering texts, but we see that it is limited to coils of material which at rest satisfy Ohm's Law, equation 2, have zero charge density, and move so slowly that v^2/c^2 is negligibly small compared to 1.

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A Repulsion Motor Problem. The following is the author's answer to his previously published essay (*EE, Dec '50, pp 1087–88*).

Action of single-phase motors can be explained by the following:

The alternating field can be thought of as being composed of two inverse rotating magnetic fields with one-half the amplitude of the original field. In practice this would be a 3-phase motor with two inverse field windings. Then there will be two magnetic fields rotating in opposite directions. It is possible now to transpose these rotating fields to an alternating field with double amplitude. At standstill, both the inversely rotating fields generate an electromotive force in the armature by induction. The armature, in turn, will cause two inverse rotating fields again.

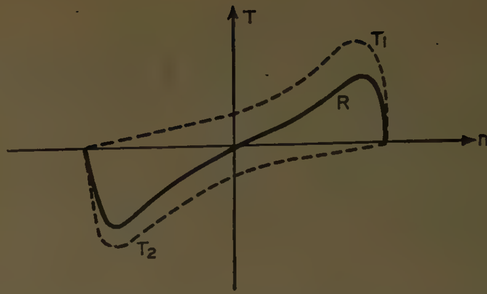

Figure 1. Two rotating magnetic fields in operation

Figure 1 shows graphically the two rotating magnetic fields in operation, where T=torque; R=resultant torque and n=revolutions per minute. Torque is nullified by the inversion of the fields.

In starting the armature with an auxiliary motor, one of the rotating fields is favored. It grows along the T_1 curve of the diagram. The other field follows the T_2 curve.

Regarding the problem, one of the T curves is suppressed and the other is reinforced (dotted lines) by the means described here. Of course, it is rather difficult to check the conditions that really take place to prevent the armature from starting by itself.

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Radio and Electric Trucks Form Team to Create New Handling Savings

Driver of the electric truck has just deposited a load at the outbound shipping dock. Without dismounting from the truck, and even before the forks leave the pallet, he is able to call the dispatcher for his next assignment

Use of 2-way radio as an aid to mechanized handling of materials is saving American industry thousands of dollars. The new technique accomplishes two purposes: it keeps industrial trucks busy carrying payloads instead of wasting time deadheading, and it moves them to busy spots where they are needed without a wasted minute. One firm putting the idea to work is the Johnson and Johnson company, whose new shipping center is at Metuchen, N. J. Internal handling, except for a dragline operating in the order picking area, is by a fleet of seven Skylift electric fork trucks, 2,000-pound capacity, made by the Automatic Transportation Company, Chicago, Ill. Two-way Motorola short-wave radio sets were installed on each of the Skylifts. They are placed to the right of the driver's seat, and are easily accessible. All sets, plus the master station from which all orders emanate, are on the same frequency. Thus, every driver hears all messages and can better orient himself to the entire operation. A master short-wave station is located in central dispatching headquarters, which is both the voice and brain of the materials' handling system. Included are a space layout chart and stock record location cards. The dispatcher knows where all merchandise is, can keep up to the minute on the positions of his fleet, and is able to shift trucks and goods with exceptional speed.

NSTITUTE ACTIVITIES

951 Winter General Meeting to Have Largest Program in Institute History

The AIEE Winter General Meeting to be ld at the Hotel Statler in New York, Y., January 22–26, will feature an panded program of professional and social ivities. The technical program is the gest in the history of the Institute with available meeting rooms in constant use. group of inspection trips also has been anged closely allied with the technical sions and conferences.

During the meeting three medals will be esented to Institute members at General ssions to be held the afternoons of January , January 23, and January 24. The Edison edal was awarded to O. B. Blackwell, d details of the award appear on page 83. e John Fritz Medal was awarded by the ir founder societies to Vannevar Bush. e Hoover Medal was awarded to Dr. T. Compton, Chairman, Corporation of assachusetts Institute of Technology. Dr. mpton, in responding to the presentation, ll speak on the subject "Engineers and tional Security."

The Alfred Noble Prize for an outstanding chnical paper by an author under 31 years of age has been awarded to R. J. Kochenburger, an Associate of the Institute. The Alfred Noble Prize is a joint interest of the various Founder Societies and the Western Society of Engineers. This award will be made, together with the 12 Institute Prize Paper Awards, in a general session to be held Monday afternoon, January 22.

On the social side, there will be a dinner-dance, a smoker, theater tickets for out-of-town members, and special entertainment for the ladies.

TECHNICAL PROGRAM

The technical program and the committee meetings will be held in the Hotel Statler. The subjects of the various sessions and the tentative titles and authors of the papers which are to be presented will be found in the following:

Sessions pertaining to communications will cover recent developments in electronic telegraph methods, advances in the communication switching art, a new carrier system for medium-haul telephone circuits, new paths under the sea, radio communication, point-to-point and mobile and color television. The conference on color television promises to be one of the most attractive because of the current interest in the subject.

The Science and Electronics Group has arranged for technical sessions on the following subjects: computing devices; nucleonic instruments; magnetic amplifiers; electronic instruments; electrical properties of gases; instruments and measurements; insulating oil testing; new electronic devices; power tubes for induction and dielectric heating; radiation detection devices; semiconductors; electronic education; electronic power converters and magnetics.

Sessions on general applications will include these subjects: fluorescent lamp ballasts; light and heavy traction; and electrical applications in hazardous areas.

The Industry Group's sessions will cover electric space heating and heat pumps; industrial control; feedback control systems; electric cables for chemical plants; cathodic protection; industrial power systems; and electric welding.

The Power Group has arranged for sessions covering relays; instrument transformers; protective devices; rotating machinery; transformers; insulated conductors; transmission and distribution; substations; system engineering; power generation and switchgear.

One of the most timely sessions is a panel discussion on operation of power, communication, and transportation utilities under military attack. Leading authorities will take part in the discussion. In addition, a session will be sponsored by the Committee on Education on graduate study in electrical engineering. The Committee on Management has also scheduled a session on management developments and the organization for the war effort.

INSPECTION TRIPS

A program of inspection trips of technical and general interest has been arranged for those attending the Winter General Meeting. A schedule and brief description are given here. Since the number who may be accommodated in most of these trips is limited, members are urged to make arrangements for trips immediately upon registering at meeting Headquarters. Advance registration by mail for inspection trips cannot be accepted.

Radio City Music Hall (Tuesday Morning, January 23). The Radio City Music Hall, New York City's most outstanding modern theater, is famous for its entertainment quality and its application of engineering developments to the entertainment field. The trip is a backstage tour to see the extensive mechanical and electric equipment

(*Continued on page 76*)

Future AIEE Meetings

EE/IRE/NBS Conference on High-equency Measurements (*page 78*)
otel Statler, Washington, D. C.
nuary 10–12, 1951

inter General Meeting (*page 71*)
otel Statler, New York, N. Y.
nuary 22–26, 1951
inal date for submitting papers—closed)

uthern District Meeting (*page 83*)
iami, Fla.
ril 11–13, 1951
inal date for submitting papers—January 11)

rth Eastern District Meeting
racuse, N. Y.
ay 2–4, 1951
inal date for submitting papers—February 1)

eat Lakes District Meeting
adison, Wis.
ay 17–19, 1951
inal date for submitting papers—February 16)

mmer General Meeting
yal York Hotel, Toronto, Ontario, Canada
ne 25–29, 1951
inal date for submitting papers—March 27)

cific General Meeting
rtland, Oreg.
gust 20–23, 1951
inal date for submitting papers—May 21)

ll General Meeting
otel Cleveland, Cleveland, Ohio
tober 22–26, 1951
inal date for submitting papers—June 22)

The new Signal Corps-developed 10,000-gram balloon is being launched at Fort Monmouth, N. J., carrying aloft radiosonde equipment to altitudes in excess of 140,000 feet for obtaining meteorological data from the upper atmosphere. An all-day tour will be made to Fort Monmouth during the Winter General Meeting

Tentative Technical Program

Winter General Meeting, New York, N. Y., January 22-26

Monday, January 22

10:00 a.m. Relays and Instrument Transformers

51-42. Relay Protection of A-C Generators. *Project Committee on Generator Protection*

CP. Ground Relay Protection for Generators.** *E. T. B. Gross*, Illinois Institute of Technology

51-38. Bibliography of Relay Literature 1947–1949. *Project Committee on Relay Bibliography.* Presentation by title only

51-113–ACO.* Report on Transformer Magnetizing Current and Its Effect on Relaying and Oil Switch Operation. *Subcommittee on Magnetization Characteristics of Transformers*

CP. Overvoltage Caused by Current Transformers in a Generator Differential Relaying Circuit.** *C. R. Mason*, General Electric Company

51-133–ACO.* A Report on Proposed Changes in the Standards for Instrument Transformers. *Project Subcommittee on Rating Factors for Instrument Transformers*

51-14. Neutral Inversion of a Single Potential Transformer Connected Line-to-Ground on an Isolated Delta System. *L. L. Gleason*, Puget Sound Power and Light Company

10:00 a.m. Insulating Oil Testing

CP. Current Practices in Electrical Tests on Dielectrics in the Field.** *Subcommittee on Electrical Tests on Dielectrics in the Field*

51-43–ACO.* Insulation Field Test Results. *W. F. Dunkle*, Pennsylvania Power and Light Company

51-37–ACO.* Power-Factor Testing of Electric Equipment to Determine Insulation Values. *J. A. Rawls*, Virginia Electric and Power Company

CP. A New Concept of Insulating Oil Characteristics.** *F. C. Doble*, Doble Engineering Company

10:00 a.m. New Types of Power Rectifiers

CP. The Mechanical Rectifier.** *Otto Jensen*, I-T-E Circuit Breaker Company

CP. Commutating Reactor Control for Mechanical Rectifiers.** *E. J. Diebold*, I-T-E Circuit Breaker Company

CP. Development of a Pumpless Ignitron.** *C. C. Herskind, E. J. Remscheid*, General Electric Company

CP. Studies of Degassing Processes by Mass Spectrometer.** *J. G. Neuland*, General Electric Company

CP. Application of Pumpless Rectifiers.** *Ralph Siegel*, General Electric Company

51-131. Sealed Ignitron Rectifiers for Urban Transit Power Supply. *D. W. Borst*, General Electric Company. Presentation by title only

10:00 a.m. Basic Sciences

51-44. Transmission-Line Load Impedance for Maximum Efficiency. *S. G. Lutz*, Bronxville, N. Y.

51-45. Networks for Which Magnitude or Phase Angle of Input Impedance or Transfer Admittance Remains Constant as Load Varies. *R. S. Berkowitz*, University of Pennsylvania

51-46. The Generalized Transmission Matrix Stability Criterion. *P. M. Honnell*, Washington University

51-47. Loci of Complex Impedance and Admittance Functions. *E. L. Michaels*, The Rauland Corporation

51-48. Contact Transients in Simple Electric Circuits. *F. E. Martin, H. E. Stauss*, Naval Research Laboratory

51-49–ACO.* The Finite Representation of Impulse Functions in Solving Differential Equations. *J. J. Smith, P. L. Alger*, General Electric Company

* ACO: Advance copies only available; not intended for publication in *Transactions*.

** CP: Conference paper; no advance copies are available; not intended for publication in *Transactions*.

51-50. Calculation of Flux Distributions with Saturation. *H. Poritsky*, General Electric Company. Presentation by title only

51-6. Tables of Green's Functions, Fourier Series, and Impulse Functions for Rectangular Co-ordinate Systems. *J. J. Smith*, General Electric Company. Presentation by title only

2:30 p.m. General Session

Address by *President T. G. LeClair*

Presentation of Student Prizes

Presentation of Institute Prizes for Papers: two each in each of the five divisions

Presentation of **Alfred Noble Prize** to *Professor R. J. Kochenburger*, Assistant Professor of Electrical Engineering, University of Conn.

Presentation of **Hoover Medal** to *Dr. K. T. Compton*, Chairman, Corporation of Massachusetts Institute of Technology

Acceptance address: **Engineers and National Security**, *Dr. K. T. Compton*

Tuesday, January 23

9:30 a.m. Operation of Power, Communication, and Transportation Utilities Under Military Attack—Panel Discussion

The present national emergency has given rise to considerable civil defense activity by the federal, state, and local governments. Substantial information pertaining to the efficiency of modern military weapons, particularly the atom bomb, has now been made available and plans for operation under military attack are being formulated by utility companies. These two sessions will be devoted to a panel discussion of the atom bomb and its effects, radioactivity associated with an atom bomb blast, various instruments for indicating radioactivity, and steps being taken by power, communication, and transportation companies for the mobilization of these industries to cope with emergencies resulting from military attack which may be imminent and which would greatly exceed operating emergencies ordinarily encountered during peacetime. There will be ample time for discussion of questions from the floor. The discussion is being sponsored by the following committees: Basic Sciences; Communications; Land Transportation; Power Generation; Industrial Power Systems; System Engineering and Nucleonics.

9:30 a.m. Relays and Industrial Power Systems

CP. Relaying of Interconnections Between Industrial and Utility Generating Systems.** *Project Committee on Relaying of Interconnections Between Industrial and Utility Generating Systems*

CP. Industrial Power System Protection.** *J. E. Barkle, H. G. Barnett*, Westinghouse Electric Corporation

CP. Bendix Products Division's Seven Years' Operating Experience with Split Bus Substation.** *T. W. Dugdale*, Indiana and Michigan Electric Company; *K. K. Falk*, Bendix Aviation Corporation

CP. Relay Protection of Mobile Alabama Alumina Plant.** *P. H. Kimmel*, Aluminum Ore Company

9:30 a.m. Electronic Instruments

CP. The NOL Self-Contained Multichannel Cathode-Ray Recorder.** *S. H. Silver*, United States Naval Ordnance Laboratory

CP. Dynamic Strain Analysis.** *C. M. Hathaway, K. C. Rock*, Hathaway Instrument Company

CP. Polarimeter for the Study of Low-Frequency Echoes.** *A. H. Benner, H. J. Nearhoof*, Pennsylvania State College

CP. New Oscillograph Recording Cameras.** *H. P. Mansberg*, Allen B. Du Mont Laboratories, Inc.

CP. Electronic Counting of Worn-Out Paper Money.** *H. M. Joseph*, National Bureau of Standards

9:30 a.m. Magnetic Materials

CP. Electronic and Nuclear Magnetic Resonance** *K. K. Darrow*, Bell Telephone Laboratories, Inc.

CP. Structure and Properties of the Ferrite** *F. G. Brockman*, Philips Laboratories

CP. Measurement Technique for Magnetic Materials in the Frequency Range 10^6 to 2.5×10 Cycles per Second.** *W. B. Westphal*, Massachuset Institute of Technology

CP. Production and Properties of Magneti Materials Used at High Frequencies.** *E. Alber Schoenberg*, General Ceramics and Steatite Corporation

9:30 a.m. Electric Cable in Chemica Plants

CP. An Installation of 15-Kv Polyethylene Insulated Cable.** *P. N. Lubke*, Ford, Bacon and Davi Inc.

CP. Conference Papers on The Installation Electric Cables in Chemical Plants:** *E. W. Davi* Simplex Wire and Cable Company; *R. C. Grahan* Rome Cable Corporation; *W. P. Lewis*, The America Steel and Wire Company

9:30 a.m. Management

CP. The Organization for the War Effort.** *Lesl E. Simon*, Brigadier General, United States Army

CP. Management Development.** *William Malone* Esso Standard Oil Company

9:30 a.m. Industrial Control

CP.A New D-C Contactor—Laboratory and Fiel Development.** *F. C. Iglehart, B. C. Wells*, Westinghou Electric Corporation

51-51. An Electronic Power Source for Large D- Contact Testing. *D. L. Pettit*, Square D Company

51-52–ACO.* Instrumentation for Analysis Contact Wear. *M. R. Swinehart*, Cutler-Hammer, In

9:30 a.m. Semiconductors

CP. Germanium Photocells.** *Mrs. F. A. Sta* Sylvania Electric Products

CP. Noise Due to Current in Semiconductor** *S. J. Angello*, Westinghouse Electric Corporation

CP. Circuit Application Problems in Transistor** *C. B. Brown*, Naval Ordnance Laboratory

1:45 p.m. General Session

Presentation of **John Fritz Medal** to *Vannevar Bu* President of Carnegie Institution of Washington

2:30 p.m. Operation of Power, Com munication, and Transporta tion Utilities Under Militar Attack—Panel Discussion Con tinued

2:30 p.m. Protective Devices

51-63. Some Effects of Lightning-Arrester Prote tive Characteristics and Location Upon Station App ratus Protection. *J. W. Kalb*, Ohio Brass Compa

51-64. Application of Resonant Grounding Power Systems in the United States. *E. T. B. Gro* Illinois Institute of Technology; *E. W. Atherton*, Dre Hill, Pa.

51-65. A Study of Conduction Phenomena Ne Current Zero for an A-C Arc Adjacent to Refracto Surfaces. *T. E. Browne, Jr., A. P. Strom*, Westinghou Electric Corporation

51-66. Power System Fault Control. *Working Gr on Power System Fault Limitation*

51-1. The Power Interruption Testing of Lightni Arresters. *Otto Ackermann*, Westinghouse Elect Corporation

CP. Standardization of Rating of Neutral Groun ing Reactors.** *J. L. Thomason*, General Elect Company

2:30 p.m. Nucleonic Instruments

CP. Instrumentation in the Civil Defense P gram.** *R. L. Butenhoff*

CP. A Portable Gamma Scintillation Coun** *C. J. Borkowski, R. A. Dandl*

** Vibrating Reed Recording Electrometer. . Werme

** Ion Current Measurements with Stabilized o. A. J. Williams, Jr., R. E. Watson, W. R. Clark, G. Amey, Leeds and Northrup Company

0 p.m. Therapeutics

** The Bases for Establishment of Maximum rgy Ratings for X-Ray Tubes. T. H. Rogers, hlett Laboratories, Inc.

** High-Speed Exposure Timing in the Applica- of X Rays. R. L. Wright, Westinghouse Electric poration

** The Electrical Conductivity of Cadmium phide When Exposed to Pulsating X-Radiation. . Jacobs, General Electric X-Ray Corporation

** The Intensification of X-Ray Fluorescent ges. W. S. Lusby, Westinghouse Electric Corpora-

** A Rotating Anode Tube for Medium Powered -Rectified X-Ray Equipment. W. W. Lang, ska X-Ray Tube Corporation

0 p.m. Electrical Breakdown in Gases

** Electrical Breakdown in Gases at High ssure. J. G. Trump, Massachusetts Institute of hnology

** Electrical Breakdown of Very Short Gaps. I. Germer, Bell Telephone Laboratories, Inc.

** The Role of Corona Discharge in the Elec- al Precipitation Process. H. J. White, Research poration

30 p.m. Industrial Control

13. Transient Response of Saturable Reactors h Resistive Load. H. F. Storm, General Electric npany

** Electronically Controlled Half-Wave Excita- for D-C Shunt Motors. W. S. Kupfer, Jr., E. E. er, Rensselaer Polytechnic Institute

** A Short-Cut Method for Determining the l Temperature Rise of Solenoids on Duty Cycle. M. Spitler, General Electric Company

** Hermetically Sealed Components for In- trial Control. E. B. Steinberg, Remington Rand, Inc.

30 p.m. Sections Committee Meeting

30 p.m. Cathodic Protection

** The Electrical Nature of Corrosion and hodic Protection. H. D. Holler, National Bureau tandards

** Cathodic Protection of Water Storage Tanks. W. Hosford, Harco Corporation

** Economic Aspects of Cathodic Protection. M. Wainwright, University of Illinois

ednesday, January 24

30 a.m. Transformers

13–ACO.* Report on Transformer Magnetizing rent and Its Effect on Relaying and Oil Switch ration. Subcommittee on Magnetization Characteristics ransformers

** Inrush Currents. W. H. Mutschler, Allis- lmers Manufacturing Company; L. A. Finzi, negie Institute of Technology

3. Transformer Magnetizing Inrush Current. R. Specht, Westinghouse Electric Corporation

4–ACO.* Improved Core Form Transformer ding. E. J. Grimmer, W. L. Teague, Westinghouse tric Corporation

5. An Investigation of Audio Noise in Sub- on Type Transformers. J. H. Vivian, Southern fornia Edison Company; R. R. Peck, Line Material pany

6. Acoustic Models of Transformer Installations. s Gettys, W. B. Conover, General Electric Company

0 a.m. Insulation

* Evaluation of Insulation Materials. F. n, Jr., A. Pletenik, G. W. Young, General Electric pany

27. A-C and D-C Voltage Endurance Studies on Mica Insulation for Electric Machinery. G. L. Moses, Westinghouse Electric Corporation

51-69. Aging of Class-B Insulating Material in Nitrogen. H. C. Stewart, L. C. Whitman, General Electric Company

51-128–ACO.* D-C Overpotential Testers for High-Voltage Insulation Fault Detection. F. W. Atkinson, The Takk Corporation; J. K. Hewson, The John Hewson Company

51-129–ACO.* Dielectric Absorption Studies at Higher Voltages on Large Rotating Machines. W. Schneider, Westinghouse Electric Corporation

51-130–ACO.* Nondestructive Testing of Generator Insulation. E. H. Povey, F. S. Oliver, Doble Engineering Company

9:30 a.m. Electronic Education

CP.** Electronic Education Requirements for Industry. Walther Richter, Allis-Chalmers Manufacturing Company

CP.** Electronic Education Requirements for the Research Laboratory. W. G. Shepherd, University of Minnesota

CP.** Electronics in Electrical Education. J. D. Ryder, University of Illinois

9:30 a.m. Instruments and Measurements

51-57. Total Hemispherical Radiometers. J. T. Gier, R. V. Dunkle, University of California

51-28. Output Analysis and Alignment Techniques for Phase-Rotation Single Sideband Transmitters. Oliver Whitby, D. R. Scheuch, Stanford Research Institute

51-29. An Electromechanical Transducer. J. F. Engelberger, H. W. Kretsch, Manning, Maxwell and Moore, Inc.

51-58. An Electromagnetic Induction Method of Measuring Oscillating Fluid Flow. A. J. Morris, Office of Naval Research; J. H. Chadwick, Stanford University

51-59. Three-Phase Measurements of Resistance. L. W. Matsch, N. C. Basu, Illinois Institute of Technology; G. R. Horcher, University of Kansas. Presentation by title only

9:30 a.m. New Techniques of Network Synthesis

CP.** The Application of Special Functions to Network Synthesis. R. M. Fano, Massachusetts Institute of Technology

CP.** Network Synthesis without Mutual Reactance. R. J. Duffin, Carnegie Institute of Technology

CP.** Synthesis of Resistance-Capacitance Networks with Prescribed Transfer Function. A. D. Fialkow, Polytechnic Institute of Brooklyn

CP.** Transducer Design Based on Statistical Properties of the Signal. R. B. Blackman, Bell Telephone Laboratories, Inc.

9:30 a.m. Recent Developments in Electronic Telegraph Methods

51-60. An Electronic Time Division Multiplex Telegraph Set. T. A. Hansen, R. D. Slayton, Teletype Corporation

51-61. Four 2-Channel Time Division Multiplex Telegraph System for Long Distance Radio Circuits. W. C. Peterman, All American Cables and Radio, Inc.; A. Minc, Mackay Radio and Telegraph Company

51-5–ACO.* A Teleprinter Signal Bias Meter. H. F. Wilder, Western Union Telegraph Company

51-62. A Nation-wide Frequency Modulated Telegraph Network. F. B. Bramhall, L. A. Smith, Western Union Telegraph Company

CP.** An Automatic Flat Scanning Facsimile Transmitter. W. G. H. Finch, C. R. Jones, Finch Telecommunications, Inc.

9:30 a.m. Arc Welding

CP.** Report of Subcommittee on Fundamentals of Electric Arc Research. R. C. McMaster, Battelle Memorial Institute

CP.** Gas Coverage of the Inert Welding Arc. R. W. Tuthill, General Electric Company

CP.** Stud Welding Method. T. L. Hufert, Graham Manufacturing Corporation

CP.** Application and Developments in the Electric Arc Stud Welding Field. R. C. Singleton, Nelson Stud Welding Company

9:30 a.m. Electrical Applications in Hazardous Areas

CP.** Tests of Electrostatic Control Equipment for Industrial Applications. Robin Beach, Robin Beach Associates

CP.** Lightning Protection for Hazardous Buildings and Structures. J. Z. Linsenmeyer, E. Beck, Westinghouse Electric Corporation

CP.** Control Equipment for Hazardous Locations. B. M. Miniken, General Electric Company

CP.** Control Rooms versus National Electrical Manufacturers Association Enclosures for Electric Equipment. R. G. Rudrow, Atlas Powder Company

1:45 p.m. General Session

Presentation of Edison Medal to O. B. Blackwell, Assistant Vice-President (retired), American Telephone and Telegraph Company

2:30 p.m. Insulated Conductors

51-10. Radial and Tangential Stresses in Impregnated Paper Insulation. J. B. Whitehead, The Johns Hopkins University

51-9. Thermal Transients on Buried Cables. F. H. Buller, General Electric Company

51-67. 69-Kv Medium Pressure Gas-Filled Cable, Washington, D. C. H. W. Clark, Potomac Electric Power Company

51-68. Lead-Alloy Sheaths for Underground Power Cable. Herman Halperin, C. E. Betzer, Commonwealth Edison Company

51-22. Thermal Expansion Effects in Power Cables. C. S. Schifreen, Philadelphia Electric Company

2:30 p.m. Transformers

CP.** Temperature Tests on Transformers. W. C. Hughes

51-4. Deterioration of Transformer Oil and Paper Insulation by Temperatures. F. J. Vogel, C. C. Petersen, L. W. Matsch, Illinois Institute of Technology

51-69 Aging of Class-B Insulating Material in Nitrogen. H. C. Stewart, L. C. Whitman, General Electric Company

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—PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained from AIEE Order Department, 33 West 39th Street, New York 18, N. Y., as noted in the following paragraphs.

—PRICES for papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the Technical Program Committee ultimately will be published in Proceedings and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

51-135—ACO.* **Progress Report on Co-operative Tests on Aging of High Temperature Insulations.** *Subcommittee Number 5 on Co-ordinated Study of Life of Transformer Insulation*

51-132—ACO.* **Proposed AIEE Guide for Operation and Maintenance of Dry-Type Transformers with Class-B Insulation.** *AIEE Committee on Transformers Working Group Number 24*

2:30 p.m. Insulation

51-125. A Maintenance Inspection Program for Large Rotating Machines. *J. S. Johnson*, Westinghouse Electric Corporation

CP. Electrical Maintenance of Large Rotating Machines.** *H. F. McCullough*, General Electric Company

51-126 Routine Insulation Testing of Synchronous Machines. *L. F. Hunt, J. H. Vivian*, Southern California Edison Company

51-41. Detection of Turn-to-Turn Faults in Large High-Voltage Turbine Generators. *R. M. Sexton, R. J. Alke*, Westinghouse Electric Corporation

CP. A-C and D-C Dielectric Breakdown Testing of a Large Turbine-Generator Stator.** *E. R. Morris*, Philadelphia Electric Company; *R. D. Case*, Westinghouse Electric Corporation

CP. Turn-to-Turn Insulation Overpotential Tests and General Dielectric Tests of a Turbogenerator.** *H. C. Marcroft*, Pennsylvania Water and Power Company

2:30 p.m. Magnetic Amplifiers

51-71. Progress Report of the AIEE Magnetic Amplifier Subcommittee. *Subcommittee on Magnetic Amplifiers*

51-72. Steady-State Analysis of Self-Saturating Magnetic Amplifiers Based on Linear Approximations of the Magnetization Curve. *W. H. Esselman*, Westinghouse Electric Corporation

CP. Transient Response of Magnetic Amplifiers.** *L. A. Finzi, D. P. Chandler, D. C. Beaumariage*, Carnegie Institute of Technology

CP. Magnetic Amplifiers using Ferrite Cores.** *W. C. Johnson*, Princeton University

2:30 p.m. Instruments and Measurements

51-30. Frequency Compensation of A-C Instruments. *J. H. Miller*, Weston Electrical Instrument Corporation

51-3. Marking of Varmeters. *Subcommittee on Marking of Varmeters and Related Instruments*

51-74. A Winding Insulation Tester for D-C Armatures. *F. H. Catlin, N. Rohats*, General Electric Company

51-75. A Hook-on Power Factor Meter. *A. J. Corson, A. L. Nylander*, General Electric Company

2:30 p.m. Advances in the Communication Switching Art, Telephone and Telegraph

51-76. A Full Automatic Private Line Teletypewriter Switching System. *W. M. Bacon, G. A. Locke*, Bell Telephone Laboratories, Inc.

51-77—ACO.* **Public Address System Used in Western Union Reperforator Switching Centers.** *R. W. Good*, The Western Union Telegraph Company

51-78. Automatic Trunk Selection in Reperforator Switching. *W. B. Blanton*, The Western Union Telegraph Company

51-79. Signal Frequency Signaling System for Supervision and Dialing Over Long-Distance Telephone Trunks. *N. A. Newell, A. Weaver*, Bell Telephone Laboratories, Inc.

2:30 p.m. Graduate Study in Electrical Engineering

CP. Mathematics in Electrical Graduate Education.** *E. W. Anderson*, Iowa State College

CP. Graduate Examination Procedures.** *J. G. Brainerd*, University of Pennsylvania

CP. The Importance of Graduate Work in the Power Field.** *W. A. Lewis*, Illinois Institute of Technology

2:30 p.m. Resistance Welding

51-140. Electrical Contact Resistance—the Contribution of Nonuniform Current Flow. *W. B. Kouwenhoven, W. T. Sackett, Jr.*, The Johns Hopkins University

51-141. Selection of Fuses for Resistance Welding Machines. *C. B. Stadum*, Westinghouse Electric Corporation

CP. Resistance Welding Transformers.** *Karl Sarafian*, General Motors Corporation

CP. Magnetic Force Welder.** *Jerome Welch*, Cutler-Hammer, Inc.

CP. Fusionette Welding Equipment.** *Harry Marx*, Primeweld Corporation

Thursday, January 25

9:30 a.m. Transmission

51-80. Techniques of Corona Loss Measurement and Analysis—500-Kv Test Project of the American Gas and Electric Company. *O. Naef*, American Gas and Electric Service Corporation; *R. L. Tremaine, A. R. Jones*, Westinghouse Electric Corporation

51-12. Corona Investigation on Extra-High-Voltage Lines—500-Kv Test Project of the American Gas and Electric Company. *I. W. Gross, O. Naef*, American Gas and Electric Service Corporation; *C. F. Wagner, R. L. Tremaine*, Westinghouse Electric Corporation

51-40. Radio Influence Tests in Field and Laboratory—500-Kv Test Project of the American Gas and Electric Company. *G. D. Lippert, S. C. Bartlett*, American Gas and Electric Service Corporation; *W. E. Pakala, C. D. Fahrnkopf*, Westinghouse Electric Corporation

CP. System Economics of Electric Power Transmission at Extra High Voltage.** *H. P. St. Clair, E. L. Peterson*, American Gas and Electric Service Corporation

51-11. The 300/315-Kv Extra-High-Voltage Transmission System of the American Gas and Electric Company. *Philip Sporn, E. L. Peterson, I. W. Gross, H. P. St. Clair*, American Gas and Electric Service Corporation

9:30 a.m. Transformers

51-39—ACO.* **Single-Step Voltage Regulator Application.** *R. W. Schlie*, Rural Electrification Administration

CP. The Effect of Voltage Variations on Voltage Regulator Design.** *D. R. Samson*, General Electric Company

51-81—ACO.* **Insulation Co-ordination and a New Line of Oil-Insulated Potential Transformers.** *F. J. Vogel*, Illinois Institute of Technology; *D. R. Laib*, Allis-Chalmers Manufacturing Company

51-2. A 2,000,000-Kva Transformer Core. *W. C. Sealey*, Allis-Chalmers Manufacturing Company

51-136—ACO.* **Report of Working Group on Dielectric Tests.** *Subcommittee on Revision of Dielectric Tests*

51-70. Economics of Power Transformer Application. *J. E. Barkle, R. L. Witzke*, Westinghouse Electric Corporation. Presentation by title only

9:30 a.m. Insulation and Synchronous Machinery

51-121. A New High-Voltage Insulation for Turbine-Generator Stator Windings. *C. M. Laffoon, C. F. Hill, G. L. Moses, L. J. Berberich*, Westinghouse Electric Corporation

CP. Turbogenerator for Use in Short-Circuit Testing.** *Sterling Beckwith*, Allis-Chalmers Manufacturing Company

51-122. Synchronous Machine Damping and Synchronizing Torques. *Charles Concordia*, General Electric Company

51-123. Factors Affecting Minimum Surface Leakage Distances in D-C Power Systems. *J. E. Hart*, Naval Research Laboratory; *W. W. Rosenberry*, Naval Engineering Experiment Station; *A. T. McClinton*, Naval Research Laboratory

51-124. Telephone Influence Factor in Synchronous Machines. *G. L. Oscarson, I. C. Benson*, Electric Machinery Manufacturing Company. Presentation by title only

9:30 a.m. Radiation Detection Devices

CP. Scintillation Counters.** *George Morton*, Radio Corporation of America Laboratories

CP. Quenching and Lifetime of Geiger-Muller Counters.** *J. B. H. Kuper*, Brookhaven Natio[nal] Laboratory

CP. Electrometer Tubes.** *D. L. Collins*, Victor[een] Instrument Company

CP. Calibration of Radiation Detection Devi[ces].** *G. Failla*, Columbia University

9:30 a.m. Computing Devices

51-82. The Input-Output System of the EDV[AC]. *R. L. Snyder, Jr.*, Aberdeen Proving Ground

CP. Improvement in the Security of Large Mas[ses] of Valuable Records by Use of Computer Techniqu[es].** *S. N. Alexander*, National Bureau of Standards

51-83. A Method of Gating for Parallel Compute[rs]. *A. G. Ratz, V. G. Smith*, University of Toronto

51-84. Systematization of Tube Surveillance [in] Large-Scale Computers. *Homer Spence*, Aberde[en] Proving Ground

51-85—ACO.* **Design of a Flip-Flop by Lin[ear] Circuit Analysis.** *J. F. Donan*, Computer Resea[rch] Corporation; *L. D. Hindall*, Los Angeles, Calif.

9:30 a.m. A New Carrier System f[or] Medium-Haul Telephone C[ir]cuits

51-86—ACO.* **The Type N-1 Carrier Telepho[ne] System Objectives and Transmission Features.** *S. Caruthers*, Bell Telephone Laboratories, Inc.

51-87—ACO.* **N-1 Carrier Telephone System A[p]paratus and Equipment.** *W. E. Kahl, L. E. Peders[en]*, Bell Telephone Laboratories, Inc.

CP. The Type N-1 Carrier Telephone System Engineering and Application.** *A. B. Covey, H. Huntley*, American Telephone and Telegraph Compa[ny]

9:30 a.m. Industrial Power Systems

CP. Parallel Operation of Industrial Generati[ng] Plants and Public Utility Systems.** *G. C. Harness, E. Grosser*, Westinghouse Electric Corporation

CP. Utilization of Purchased Electric Power in [an] Oil Refinery.** *A. J. Claes*, Socony-Vacuum Oil Co[m]pany

CP. Industrial Plant Power Sources.** *R. Woodruff*, Aluminum Ore Company

CP. Emergency Electric Generating Plant.** *F. Thomas, Jr.*, N. A. Lougee and Company

9:30 a.m. Electric Space Heating a[nd] Heat Pumps

CP. Five All-Electric Homes Using the H[eat] Pump for Year-Round Air Conditioning.** *E. Ambrose*, American Gas and Electric Service Corporati[on]

CP. Ignition Delay in Oil Burners.** *F. Hamburg[er], Jr.*, The Johns Hopkins University

CP. Electric Panel Heating.** *C. Frere*, Gene[ral] Electric Company

CP. Controls for Heat Pump Applications.** *F. Snyder*, Minneapolis-Honeywell Regulator Compa[ny]

2:00 p.m. Capacitors

51-15. Application of Shunt Capacitors at Tra[ns]mission and Distribution Stations. *F. M. Porter, P. Zimmerman*, American Gas and Electric Serv[ice] Corporation

51-88. Technical Problems Associated with t[he] Application of a Capacitor in Series with a Synch[ro]nous Condenser. *R. L. Witzke*, Westinghouse Elect[ric] Corporation; *E. L. Michelson*, Commonwealth Edis[on] Company

51-89. Fundamental Effects of Series Capacitors [in] High-Voltage Transmission Lines. *A. A. Johns[on], J. E. Barkle, D. J. Povejsil*, Westinghouse Electric C[or]poration

51-20. The Application of a Series Capacitor to Synchronous Condenser for Reducing Volta[ge] Flicker. *P. M. Black*, Illinois Northern Utilit[ies] Company; *L. F. Lischer*, Commonwealth Edison Co[m]pany

2:00 p.m. Substations

51-90. D-C Power Supplies and Isolation of Fa[ults] on Electric Transit Systems—Part I. *S. S. Walt[...]*, Gibbs and Hill, Inc.; *M. E. Reagan*, Westingho[use] Electric Corporation

51-91. D-C Power Supplies and Isolation of Fa[ults]

lectric Transit Systems—Part II. *S. S. Watkins,* s and Hill, Inc.; *M. E. Reagan,* Westinghouse ric Corporation

2. **Group Regulation of Urban 4-Kv Feeders.** *Grim, H. B. Peck,* Consolidated Gas, Electric Light, Power Company of Baltimore

* **The Trend Toward Bus Regulation on the** **em of the Detroit Edison Company.** *I. S. Menden-* Detroit Edison Company

* **Considerations That Led to Radial Distribu-** **with Bus Regulation in Preference to Primary** **econdary Networks in the City of Los Angeles.** *V. Eardley,* Department of Water and Power, The of Los Angeles

0 p.m. Symposium on the Determination of What Units in What Plants should be Used for Load and Frequency Control

** **Introduction to the Subject.** *S. B. Morehouse,* ls and Northrup Company

** **Allocation and Assignment of Frequency** **Line Control.** *G. H. McDaniel,* American Gas and tric Service Corporation

** **Methods of Scheduling Load Regulation** **en Using Automatic Load Control.** *A. P. Hayward,* uesne Light Company

** **The Determination of What Units in What** **ts on a System should be Assigned to Load** **ulation.** *E. C. Stewart,* Middle South Utilities pany

** **Load Regulation Practices of Cincinnati Gas** **Electric Company.** *S. Goldsmith,* Cincinnati Gas Electric Company

** **Assignment of Load Regulating Burden to** **ions of the Commonwealth Edison Group of** **panies.** *R. T. Purdy,* Commonwealth Edison pany

0 p.m. Power Tubes for Electronic Heating

** **Tubes for Dielectric Heating at 915 Mega-** **es.** *R. B. Nelson,* General Electric Research Labora- s. Presentation by *P. W. Morse,* General Electric pany

** **Selection and Application of Tubes for In-** **tion and Dielectric Heating.** *H. J. Dailey, C. H.* *en,* Westinghouse Electric Corporation

** **The Design of High-Power Vacuum Tubes** **Industrial Heating Applications.** *H. B. Doolittle,* chlett Laboratories

** **A Very-High-Frequency High-Power Triode.** *Schmitt,* Federal Telephone and Radio Corporation

00 p.m. Analogue Computers

s session will be composed of the following technical er and several conference papers dealing with ous aspects of the design and application of electric ogue computers.

3. **Analogue Computing Techniques Applied** **conomics.** *R. H. Strotz, J. F. Calvert, N. F. More-* , Northwestern University

00 p.m. Electronic Paths Under the Sea—Centenary

** **The Genesis of Submarine Cables.** *L.* *nschied,* Bell Telephone Laboratories, Inc.

** **Submerged Repeaters for Long Submarine** **graph Cables.** *C. H. Cramer,* Western Union graph Company

4. **A Submarine Telephone Cable with Sub-** **ged Repeaters.** *J. J. Gilbert,* Bell Telephone oratories, Inc.

00 p.m. Industrial Power Systems

** **High-Voltage Motor Starters Co-ordinated** **Distribution Switchgear.** *T. B. Montgomery,* -Chalmers Manufacturing Company

** **Power Modernization of an Old Plant.** *A.* *Howard,* General Electric Company

* **Power Distribution System Expansion—** **lehem Steel Company, Lackawanna Plant.** *T.* *ittel,* Bethlehem Steel Company; *R. M. Wilson,* eral Electric Company

* **Power Distribution System of the United** **s Government Accounting Office Building,** Washington, D. C. *F. J. Muller,* Public Building Service; *D. S. Brereton,* General Electric Company

2:00 p.m. The Measurement and Control of Audible Noise from Fluorescent Lamp Ballasts

CP. The Effect of Ambient Noise Level and Human Factors on the Evaluation of Acceptable Ballast Noise Limits.** *C. H. Burns,* Westinghouse Electric Corporation

CP. Measurement of Audio Ballast Noise.** *H. U. Hjermstad,* Sola Electric Company

CP. Testing Fluorescent Fixtures for Noise.** *R. D. Eames,* Mitchell Manufacturing Company

51-95. Noise Evaluation of Fluorescent Lamp Ballasts. *C. P. Hayes, H. R. Gould,* General Electric Company. Presentation by title only

Friday, January 26

9:30 a.m. Capacitors and Switchgear

51-19. Switching of Distribution Capacitors by Manual and Automatic Devices. *R. J. Hopkins, N. R. Schultz,* General Electric Company

51-18. Switching High-Voltage Shunt Capacitor Banks. *A. W. Funkhouser,* Indianapolis Power and Light Company; *R. C. Van Sickle, D. F. Shankle,* Westinghouse Electric Corporation

51-21. Capacitor Switching Phenomena. *R. C. Van Sickle,* Westinghouse Electric Corporation; *John Zaborszky,* University of Missouri

CP. Capacitor Switching Oil and Air-Blast Circuit Breakers.** *A. E. Kilgour,* Allis-Chalmers Manufacturing Company

CP. Dielectric Strength of Capacitors.** *R. J. Hopkins, T. R. Walters,* General Electric Company

9:30 a.m. Power Generation

51-96. Progress in the Development of Large Turbine Generators. *E. D. Huntley, H. D. Taylor,* General Electric Company

51-97. Modern Practice in the Balancing of Large Turbine-Generator Rotors. *C. M. Laffoon, A. C. Hagg, C. H. Janthey, P. R. Heller,* Westinghouse Electric Corporation

CP. Progress and Needed Improvements to Electric Power Generating Stations and Machines.** *I. E. Moultrop, G. A. Orrok, Jr.,* Boston Edison Company

CP. Progress in Electric Machinery Control for Power System Service.** *T. B. Montgomery, R. C. Moore, W. R. Ringland, L. T. Rosenberg*

9:30 a.m. Some New Electron Tubes

CP. A Gas-Filled Resonant Window for Radar Duplexing Devices.** *E. A. Goldman, N. T. Williams,* Westinghouse Electric Corporation

CP. A High-Current Thyratron.** *A. W. Coolidge, Jr.,* General Electric Company

CP. A Tunable Miniature Magnetron.** *H. W. A. Chalberg,* General Electric Company

CP. A Permanent Magnet Electron Microscope.** *J. H. Reisner,* Radio Corporation of America

9:30 a.m. Radio Communication, Point-to-Point and Mobile

51-7. Operational Study of a Highway Mobile Telephone System. *L. A. Dorff,* Bell Telephone Laboratories, Inc.

CP. Progress in Radio-Facsimile for Telegram Delivery.** *C. Jelinek, Jr., K. R. Jones,* The Western Union Telegraph Company

CP. Description of Power Amplifier and Exciter Transmitter Units for Transoceanic Point-to-Point Communication Service.** *H. E. Goldstine, G. L. Usselman,* Radio Corporation of America Laboratories

CP. Simplified Analysis of Nonrecurrent Pulse Groups.** *L. S. Schwartz,* Hazeltine Electronics Corporation

51-98. Pulse-Time Modulation Telemetering Systems for Rocket Application. *J. T. Mengel,* Naval Research Laboratory. Presentation by title only

9:30 a.m. Feedback Control Systems

51-99. Some Design Criteria for Automatic Controls. *P. T. Nims,* Chrysler Corporation

51-100. Effects of Carrier Shifts on Derivative Networks for A-C Servomechanisms. *G. M. Attura,* Industrial Control Company

51-101. Network Synthesis by Graphical Methods for A-C Servomechanisms. *G. A. Bjornson,* Massachusetts Institute of Technology

51-102. A Note on the Design of Conditionally Stable Feedback Systems. *Paul Travers,* Massachusetts Institute of Technology

51-103. A Phase-Plant Approach to the Compensation of Saturating Servomechanisms. *A. M. Hopkin,* Northwestern University

9:30 a.m. Heavy Traction

These three papers will be a single presentation:

51-104. Selection of Equipment for Multiple-Unit Cars. *W. M. Hutchison,* Westinghouse Electric Corporation

51-36. A New Multiple-Unit Car Motor for the Pennsylvania Railroad. *H. G. Jungk,* Westinghouse Electric Corporation

51-105. New A-C Multiple-Unit Car Control for the Pennsylvania Railroad. *S. E. Newhouse,* Westinghouse Electric Corporation

These three papers will be a single presentation:

51-35. Why 4-Motor Multiple-Unit Car Equipments? *R. A. Williamson,* General Electric Company

51-106. A-C Multiple-Unit Car Motor. *F. C. Kreitler, Jr.,* General Electric Company

51-107. A-C Multiple-Unit Car Control Equipment. *W. S. O'Kelly,* General Electric Company

51-108. A New Train Performance Calculator. *S. V. Smith,* Pennsylvania Railroad

51-34. A Modern Cab Signaling and Train Control System for Railroads. *L. R. Allison,* Union Switch and Signal Company

9:30 a.m. Rotating Machinery

51-109. Circuit Analysis Method for Determination of A-C Impedances of Machine Conductors. *D. S. Babb, J. E. Williams,* University of Illinois

51-110. A Simplified Method for Predicting Induction Motor Performance. *H. E. Webking,* General Motors Corporation

51-111. An Experimental Study of Induction Machine End-Turn Leakage Reactance. *E. C. Barnes,* The Reliance Electric and Engineering Company

CP. The Development of a Treatment for Die-Cast Rotors.** *Ulrik Krabbe, Thomas B. Thrige*

51-117–ACO.* Die-Cast Rotor Studies. *L. C. Packer, G. E. Monchamp,* Westinghouse Electric Corporation

9:30 a.m. Instruments and Measurement Standards and Spectrographic Instrumentation

CP. Standards for Electrical Measurements.** *F. B. Silsbee,* National Bureau of Standards

CP. Atomic Definitions of Primary Standards.** *R. D. Huntoon,* National Bureau of Standards

CP. Some Applications of Photomultiplier Tubes in Spectrographic Analysis.** *J. K. Brody*

CP. Radio-Frequency Spectroscopy.** *D. K. Coles,* Westinghouse Electric Corporation

2:00 p.m. Transmission and Distribution

51-17. Protection of Transmission Lines over Mountainous Region Where Lightning Incidence is High. *J. E. Housley, J. D. Harper,* Aluminum Company of America

51-16. Geometric Mean Distances of Angle-Shaped Conductors. *P. C. Magnusson,* Oregon State College

51-26. A Per-Unit Interpretation of Transmission-Line Constants. *D. J. Povejsil, A. A. Johnson,* Westinghouse Electric Corporation

51-112. Eleven-Year Operating Record, Rural Line Sectionalizing by Repeater Fuses. *R. M. Schahfer, F. H. Strout,* Northern Indiana Public Service Company

2:00 p.m. Switchgear

51-25. A Spring Mechanism for Hand Closing of

Magnetic Power Air Circuit Breakers. *R. C. Dickinson, J. D. Findley*, Westinghouse Electric Corporation

51-27. A New 69-Kv Air-Blast Circuit Breaker. *R. B. Shores, J. W. Beatty*, General Electric Company

51-8. Ice Testing and Its Influence Upon Switch Design. *G. E. Heberlein, E. J. Field*, Railway and Industrial Engineering Company

CP. Application of Air Circuit Breakers in Motor Circuits.** *P. L. Camp*, General Electric Company

51-133–ACO.* Report on Transformer Magnetizing Current and Its Effect on Relaying and Air Switch Operation. *Subcommittee on Magnetization Characteristics of Transformers*. Presentation by J. M. Wallace

2:00 p.m. Hydroelectric Outage Experience

51-23. Determination of Generator Stand-by Reserve Requirements. *H. T. Strandrud*, Bonneville Power Administration

CP. Factors Determining the Optimum Capacity of an Hydroelectric Power Installation.** *J. J. Traill*, The Hydro-Electric Power Commission of Ontario

CP. Determination of Monthly Hydro Dependable Capacity, Niagara Mohawk Electric System.** *E. B. Strowger*, Niagara Mohawk Power Corporation

CP. Determination of Reserve Capacity by the Probability Method—Effect of Interconnections.** *G. Calabrese*, New York University

2:00 p.m. Some New Electronic Devices and Techniques

CP. A Metal Evaporator Using High-Frequency Induction Heating.** *R. G. Picard, J. E. Joy*, Radio Corporation of America

CP. Use of Diodes as Logarithmic Elements in Measuring and Control Equipment.** *W. M. Grim, Jr.*, Massachusetts Institute of Technology

CP. Measurement of Metal Wall Thickness from One Side by the Ultrasonic Resonance Method.** *N. G. Branson*, Branson Instruments, Inc.

CP. The Sona-Stretcher.** *H. R. Foster, E. E. Crump, J. L. Gogorth*, Kay Electric Company

2:00 p.m. Color Television

CP. Ultrahigh-Frequency Television Reception at Bridgeport.** *R. G. Clapp*, Philco Corporation

CP. Some Phases of the United States Color Television Standards.** *P. C. Goldmark*, Columbia Broadcasting System, Inc.

51-114–ACO.* A Color Television System for Industry. *H. R. Smith, A. L. Olson, R. F. Cotellessa*, Allen B. DuMont Laboratories, Inc.

CP. Fundamentals of Color Television and Their Application Today.** *A. V. Loughren*, Hazeltine Electronics Corporation

2:00 p.m. Feedback Control Systems

CP. The Effects of Loads and Disturbances Upon Feedback Controllers.** *R. W. Jones*, Northwestern University

CP. An Optimization of Resistance-Capacitance Lead Networks for Servomechanisms.** *J. R. Ragazzini, L. A. Zadeh*, Columbia University

CP. Carrier-Controlled Relay Servos.** *J. C. Lozier*, Bell Telephone Laboratories, Inc.

CP. Servomechanism Transient Performance from Decibel-Log Frequency Plots.** *H. Harris, Jr., M. J. Kirby, E. F. von Arx*, Sperry Gyroscope Company

2:00 p.m. Light Traction

CP. Power Supply Study and New Rectifier Installation for the United Electric Railways of Providence.** *W. C. Whitman, F. F. Schaller*, New England Power Service Company

51-115. Economics of Trolley Coach Power Supply. *G. R. McDonald, J. C. Price*, General Electric Company

51-33. Electric Equipment and Performance of Lightweight Rapid Transit Cars. *W. R. Ellis, M. L. Sloman*, Westinghouse Electric Corporation

51-31. A New Lightweight Rapid Transit Motor. *R. A. Pettersen*, General Electric Company

51-32. A New Lightweight Rapid Transit Control Equipment. *I. W. Lichtenfels, H. G. Moore*, General Electric Company

2:00 p.m. Rotating Machinery

51-116. Equivalent Circuits, and Their Application in Designing Shaded-Pole Motors. *S. S. L. Chang*, Robbins and Myers, Inc.

51-24. Commutation in Universal Type Motors. *L. C. Packer*, Westinghouse Electric Corporation

CP. Application of Universa Motors.** *F. J. Chayka*, General Electric Company

51-118. Measurement of D-C Machine Parameters. *R. M. Saunders*, University of California

51-119. Rules for Designing Frog-Leg Windings of D-C Machines. *H. B. Dwight, R. G. Haltmaier*, Massachusetts Institute of Technology

51-120. Fault Transients in Aircraft D-C Systems. *D. G. Scorgie*, Naval Research Laboratory

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(*Continued from page 71*)

with its intricate control systems. Revolving and sectionalized stages, lifting orchestra pits, motor-operated curtains, and fantastic lighting effects will be seen. The magnitude of these operations is indicated by 5,500 horsepower of motor and 3,500 kilowatts of connected load.

The New York Times (Tuesday Morning, January 23, and Thursday Afternoon, January 25). The Times is famous for complete and impartial news coverage of the entire world. In order to maintain this reputation, it has the most extensive news-gathering organization of any newspaper in the world. There are over 30 foreign bureaus, as well as many more part-time news contacts. In this country, there are nine bureaus, and 400 other news contacts. The Times has 50 full-time correspondents abroad, and 47 part-time correspondents. The total news intake per day is in excess of 1,000,000 words.

The Times tour is designed to give each visitor a clear picture of each operation in the complex process of producing a newspaper, from the news source to the newsstands. A competent guide directs each group, explaining operations and answering questions. In addition to the tour of the newspaper plant, each group visits the Times' radio station, WQXR, which is located in the building.

DuMont Television Receiver Manufacturing Plant (Tuesday Afternoon, January 23). This plant, the largest of its type in the United States, was placed in operation in the fall of 1948. The latest assembly techniques are employed on the numerous production lines, each line producing a different type of receiver chassis. Television receivers, from beginning to end, can be seen on this trip.

Anaconda Wire and Cable Plant (Tuesday Afternoon, January 23). This tour visits the Hastings-on-Hudson mill of the Anaconda Wire and Cable Company, one of the most modern of the larger cable mills in this country, producing hot-rolled rods, bare and coated wire, stranded conductors, weatherproof, impregnated-paper, varnished-cloth-, and plastics-insulated cables and cable accessories. The company's Research Laboratories also are located at this mill. An opportunity will be afforded to see all of the processes from rod-rolling to completion of the finished products. Special features such as the high-vacuum Taylor impregnating system, electric control of tensions during paper taping, fabrication of type-*CB* (Carbon Black) cables, and extrusion of heat-treated *F-3* alloy cable sheath are included.

North Queens Substation and the Astoria Transformer and Equipment Repair Shop (Tuesday Afternoon, January 23, and Wednesday Afternoon, January 24). This is a combination trip to the recently completed North Queens Substation and the new Astoria Transformer and Equipment Repair Shop.

The substation receives power over four 138-kv transmission cables and distributes to 14 27-kv underground network feeders. Outdoor 138-kv buses, switches, and transformers, indoor 27-kv air circuit breakers, and isolated metal-clad buses are features of this installation. The present substation capacity is 170 megawatts with provisions for future additional high- and low-tension feeders. This is the latest in Consolidated Edison's new substation project.

The Repair Shop, which was recently built to fulfill the maintenance requirements of an expanding system, has many novel features, including flow painting and a centralized oil purification and distribution control system. Operations on the completely welded-up transformer unit were developed at this shop. Numerous other features, important in the maintenance and repair of electric equipment, are to be exhibited and explained for those attending this trip.

Noncitizens of the United States must give 10-days advance notice of intention to attend.

New York Stock Exchange (Wednesday Morning, January 24, and Thursday Afternoon, January 25). This well-known institution has given permission for a limited number of persons to view its operations and to hear an explanation of its function in the economic welfare of the nation. A most interesting and informative program is provided.

Elevator Plant of the Westinghouse Electric Corporation (Wednesday Afternoon, January 24). This plant produces elevators and electric stairways for every conceivable modern structure, from the multistory business offices of Rockefeller Center to the flight-deck elevators of our modern aircraft carriers. Over 5,000 tons of steel and 6,000 miles of wire and cable are used annually at this plant. Many new features and improvements in vertical transportation were first introduced through equipment developed and produced at this plant.

United States Signal Corps Engineering Laboratories, Fort Monmouth, New Jersey (Wednesday All Day, January 24). As principal research and development center of the Signal Corps

e Signal Corps Engineering Laboratories e charged with the creative research, velopment, design, and improvement of ound signal equipment and special elec- nic devices for the United States Army, d, in many instances, for the Armed rces at large. Radio, radar, electronic untermeasures, wire, television, meteorol- y, photography, radiological detection vices, components, power units and xiliary equipments which provide the mmunication and detection systems for the my are on its agenda.

Some 2,700 scientists, engineers, and pporting personnel are collaborating to ect technological advances. Outstanding nong these during the past year was the olution of a surface-wave transmission e offering new possibilities in efficient nsmission of radio-frequency energy and new stabilization technique for rapidly ing quartz crystals with a potential saving production man-hours in procurement. vances have had a marked effect on litary and industrial techniques, especially the fields of miniaturization, climatization, d ruggedization.

Fort Monmouth is unique as one of the eatest training and technological centers its kind in the world. The tour of these boratories is restricted to United States zens.

Brooklyn—Battery Tunnel (Thursday Morn- , January 25). The longest vehicular nel in the United States, capable of ndling 16,000,000 vehicles a year, was ently opened for traffic through the dual ane tubes. A project of this magnitude sed many problems which were uniquely ved by its engineers. This tour includes sage through the tubes to see the novel mination features and a visit to the ster electric control board, the ventilating fts, and the power supply switch rooms. pendability of operation and flexibility of ntrol were stressed in the design of the ctric facilities for this tunnel.

Power Control Center and New Rectifier tion of the New York City Transit System nursday Afternoon, January 25). The d Street supervisory station controls all the automatic substations of the New rk Subway System. These substations of the automatic, unattended type and ve both rotary and rectifier equipment. e Commonwealth and Molford sub- tions each consist of two 2-unit 3,000-kw itron rectifiers recently installed and are ical of the type of conversion equipment ich is now favored for this application. ese stations are controlled from the d Street board. An opportunity will be orded to see the dispatcher's board in ration at one point and to observe the ction of another.

SMOKER

All arrangements are complete for the oular smoker on Tuesday night, January at the Hotel Commodore. Chairman M. Quick advises that the evening will n with a cocktail hour at 5:30 p.m. in West Ballroom with dinner and show to ow. Tables for ten persons will be ilable and price of the tickets will be 00 per person. Though every effort be made to meet all demands for ets, the physical limits of the room have made this difficult for several years past. Reservations should be addressed to the Smoker Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. Reservations received after January 16 will not be honored. Checks should be made payable to "Special Account, Secretary AIEE."

The Hastings-on-Hudson mill of the Anaconda Wire and Cable Company, one of the most modern of the larger cable mills in the United States, will be inspected during the 1951 Winter General Meeting in New York, N. Y.

DINNER-DANCE

At this year's meeting, members and guests again will enjoy the pleasure of a formal dinner-dance. It will be held in the Grand Ballroom of the Hotel Statler Thursday evening, January 25. Dinner will be served at 7 p.m., followed by dancing. Tables for the dinner and dance will accommodate ten persons. The price for tickets will be $11 per person.

Requests for reservations should be addressed to Dinner-Dance Committee, AIEE Headquarters, 33 West 39th Street, New York 18, New York. Checks should be made payable to "Special Account, Secretary AIEE."

LADIES' ENTERTAINMENT

An interesting program has been arranged for the entertainment of the ladies. On Monday afternoon there will be a Tea and Get-Together at Ladies' Headquarters in the Hotel Statler; Tuesday evening a dinner party and entertainment is being planned; on Wednesday the ladies are expected to take a trip to the United Nations at Lake Success, N. Y., which will probably include attendance at a session of the Security Council. However, the trip is contingent on the status of the international situation at that time. On Thursday there will be a luncheon and Fashion Show at the Plaza, and smaller sightseeing trips will be arranged on request.

THEATER TICKETS

It is expected that tickets will be available for various Broadway shows. Those members wishing seats should write AIEE Headquarters at an early date to insure best choice of seats and productions. Requests should include name of show, date, number of seats required, and check to cover cost of tickets. In the case of tickets in short supply, the right is reserved to allocate seats only to members attending from points beyond the New York metropolitan area.

Tickets are not available for:

Call Me Madam; Guys and Dolls

Some current productions and prices are:

	Evening, Orchestra	Matinee, Orchestra
Affairs of State	$4.80	$3.60
*Gentlemen Prefer Blondes	6.00	3.60
*Kiss Me Kate	6.00	3.60
The Lady's Not for Burning	4.80	3.60
Season in the Sun	4.80	3.60
The Cocktail Party	4.80	3.60
The Happy Time	4.80	3.60
The Member of the Wedding	4.80	3.60
Bell, Book and Candle	4.80	3.60

* Indicates Musical.

HOTEL ACCOMMODATIONS

Blocks of rooms have been set aside at the Hotel Statler (meeting headquarters) and near-by hotels for members attending. To assure accommodations, reservations must be received by the hotel of choice before January 12. Requests for reservations should be sent early directly to the desired

Eta Kappa Nu Association to Hold Annual Dinner

The Eta Kappa Nu Association will hold its Annual Recognition Dinner on Monday evening, January 22. This dinner will be held at 6:30 p.m. in the Blue and Green Room, Hotel McAlpin.

At this dinner, D. P. Campbell will receive the Eta Kappa Nu plaque in commemoration of his being chosen the Most Outstanding Young Electrical Engineer for 1950. Honorable Mention certificates will be awarded to R. W. Mayer, A. W. Edwards, and K. A. Kesselring, who were selected from among 50 candidates for the 1950 recognition by a jury consisting of Dr. Erich Hausmann, Dean, Polytechnic Institute of Brooklyn; A. H. Kehoe, Vice-President, Consolidated Edison Company of N. Y., Inc.; Robin Beach, Robin Beach Associates; Fischer Black, Editor, *Electrical World;* and F. E. Sanford, National President of Eta Kappa Nu Association.

hotel, and to only one hotel. A copy of the request should be sent to Mr. C. N. Metcalf, Chairman, Hotel Accommodations Committee, in care of Consolidated Edison Company of New York, Inc., Room 1250-S, 4 Irving Place, New York 3, N. Y. A second and third choice should be indicated on this copy. If requested accommodations are not available, the Hotel Accommodations Committee will arrange for transfer to one of the other hotels desired.

Hotel rooms have been reserved at:

Hotel Statler (meeting headquarters) 7th Avenue, 32d to 33d Streets	
Single room with bath	\$ 5.00 to \$ 8.50
Double room, double bed	7.50 to 10.50
Double room, twin beds	9.00 to 14.00
Parlor suites	19.00 to 33.00
Hotel McAlpin, Broadway and 34th Street	
Single room and bath	4.50 to 8.50
Double room, double bed	7.00 to 10.50
Double room, twin beds	8.50 to 11.00
Suites	14.00 to 15.00
Hotel Governor Clinton, 7th Avenue at 31st Street	
Single room with bath	4.50 to 7.00
Double room, double bed	7.00 to 10.00
Double room, twin beds	8.50 to 10.00
Hotel New Yorker, 34th Street at 8th Avenue Note: Reservations for arrival January 20th or 21st ONLY. Write to D. W. Carlton, Director of Sales.	
Single room, tub and shower	\$4.50 to \$8.00
Double room, double bed	7.50 to 12.50
Double room, twin beds	8.50 to 12.50
Suite accommodations	14.00 to 25.00
Hotel Martinique, Broadway and 32d Street	
Single room with bath	3.50 to 6.00
Double room, double bed	6.00 to 10.00
Double room, twin beds	6.50 to 10.00
Two-room suites	10.00 to 18.00
Hotel Commodore, 42d Street at Lexington Avenue	
Single room with bath	6.00 to 9.00
Double room, twin beds, bath	10.50 to 12.50

WINTER GENERAL MEETING COMMITTEE

The members of the 1951 Winter General Meeting Committee are G. J. Lowell, *Chairman;* C. T. Hatcher, *Vice-Chairman;* J. J. Anderson, *Secretary;* W. J. Barrett, *Budget Co-ordinator;* C. S. Purnell, *Vice-President, District 3, AIEE;* C. H. Willis, *Technical Program;* J. D. Tebo, D. W. Taylor, D. T. Braymer, *General Session;* N. S. Hibshman, *Medals;* G. T. Minasian, J. B. Harris, Jr., *Publicity;* C. N. Metcalf, *Hotel Accommodations;* E. R. Thomas, *Registration;* D. M. Quick, *Smoker;* Mrs. R. F. Brower, *Ladies' Entertainment;* E. S. Banghart, *Dinner-Dance;* F. P. Josslon, *Inspection Trips;* J. B. Paszkowski, *Theater-Radio.*

High-Frequency Measurements to Be First Technical Conference of 1951

The second conference on High Frequency Measurements, sponsored jointly by the AIEE, the Institute of Radio Engineers (IRE), and the National Bureau of Standards (NBS) will be held in Washington, D. C., on January 10, 11, and 12, 1951. Patterned after the successful 1949 conference, this forum will offer those interested in high-frequency measurements and measuring apparatus an opportunity to learn of new developments and exchange information on recent advances in the art.

The technical program will consist of four sessions on various categories of measurements, and an evening of demonstration lectures. Interesting inspection trips have been arranged. A luncheon on Thursday will mark the mid-point of the conference.

This conference is being held in Washington as a part of the celebration of the Semicentennial of the National Bureau of Standards. The Joint AIEE-IRE Committee on High-Frequency Measurements, the AIEE Committee on Instruments and Measurements, and the IRE Professional Group on Instrumentation have co-operated in organization of the conference.

NBS OPEN HOUSE

At 10:30 a.m. on January 10, NBS will conduct an open house as part of its semicentennial celebration. This guided tour will cover exhibits not visited during the regular NBS Conference Tour. Exhibits will include the X-ray and high-voltage laboratories where the magnetic clutch and miniaturized i-f strips will be displayed. Several new mass spectrometers will be shown, including an r-f type and a 35-ton precision cross-field instrument, as well as the cyclotron-like "omegatron." Electron-optical shadow methods and the use of mercury *198* as a wavelength standard will be shown.

LUNCHEON

AIEE President T. G. LeClair, IRE President I. S. Coggeshall, and the Director of NBS, Dr. E. U. Condon, have been invited to attend a luncheon as guests of the conference. This will be held at 12:15 p.m. January 11 at the Hotel Statler, and Ernst Weber, Chairman of the Joint AIEE-IRE Committee on High-Frequency Measurements, will preside. The luncheon charge is \$4.00 per person.

INSPECTION TRIPS

Guided tours of four outstanding Government institutions have been arranged; these are to the Bureau of Standards, Naval Observatory, Naval Ordnance Laboratory, and Naval Research Laboratory (last two restricted to citizens of the United States). Tours will be conducted Thursday, January 11, at 2:00 p.m.

National Bureau of Standards: This tour will be divided between items of general interest and those relating to radio measurements. The 50,000,000-volt betatron used for basic research and medical and industrial applications will be visited. The NBS Eastern Automatic Computer (SEAC) will be demonstrated. The new microwave and primary standards laboratories will be visited.

United States Naval Observatory: The tour will cover the newest methods used for primary time determinations and related work such as the Nautical Almanac. Points of interest are: time service laboratory; photoelectric measuring engine; 40-inch reflecting, 26-inch, and Polaris telescopes.

Naval Ordnance Laboratory: This laboratory is one of the world's largest and most modern installations devoted entirely to research and development for Naval ordnance weapons and devices. Visitors will see the famous vacuum-type supersonic wind tunnels, the unique ballistic ranges, and testing and evaluation facilities of the recently com-

Lehigh Valley Section Meets in Easton, Pa.

Members of the AIEE Lehigh Valley (Pa.) Section held a dinner meeting at the Hotel Easton on October 13 and heard Dr. Albert F. Thompson, Chief of the Technical Information Service, Washington, D. C., discuss nucleonics. Seated at the speaker's table, left to right, are: Secretary-Treasurer A. L. Price, Dr. Thompson, District Manager S. D. Henry, and Chairman G. M. Keenan

Technical Program

AIEE-IRE-NBS Conference on High Frequency Measurements

Washington, D. C., January 10–12, 1951

ednesday, January 10

30 p.m. Measurement of Frequency and Time

siding: F. J. Gaffney, Polytechnic Research and velopment Company

troductory Address: **The Impact of High-Frequency easurements on Research and Development.** *. E. U. Condon,* Director, National Bureau of Standards

ogram for Atomic Frequency and Time Standards—Survey. *Harold Lyons,* National Bureau of Standards

proved NBS Ammonia Clock. *B. F. Husten,* National Bureau of Standards

e Stabilization of a Microwave Oscillator with an nmonia Absorption Line Reference. *E. W. Fletcher, P. Cooke,* Harvard University

rformance of Oscillators Frequency Controlled by s Absorption Lines. *L. E. Norton,* Radio Corporan of America Laboratories

illimeter Wave Measurements. *Walter Gordy,* ke University

uartz-Crystal Frequency Standards. *W. D. George,* ational Bureau of Standards

igh Frequency Crystal Units for Primary Frequency andards. *A. W. Warner,* Bell Telephone Laboratories, c.

hursday, January 11

:30 a.m. Measurement of Impedance

esiding: R. A. Braden, Radio Corporation of America aboratories

flection Point Method of Measuring Q at Very igh Frequencies. *N. E. Beverly,* Sperry Gyroscope mpany

A Precise Sweep Frequency Method of Vector Impedance Measurement. *D. A. Alsberg,* Bell Telephone Laboratories, Inc.

Precision Coaxial Resonance Line for Impedance Measurements. *H. E. Sorrows, R. E. Hamilton, W. E. Ryan,* National Bureau of Standards; *M. S. Wong,* Wright Field

A 2600–4000 Megacycle VSWR Measuring Set. *S. F. Kaisel,* Radio Corporation of America Laboratories; *J. W. Kearney,* Airborne Instruments Laboratory

Measurement of Waveguide and Coaxial Line Impedances with a Circular Waveguide. *A. E. Laemmel,* Polytechnic Institute of Brooklyn

A Survey of Microwave Dielectric Techniques for Small Liquid and Solid Samples. *George Birnbaum,* National Bureau of Standards

8:15 p.m. Demonstration Lectures

This will also be the Annual Joint Meeting of the Washington Sections of AIEE and IRE.

Presiding: E. I. Green, Bell Telephone Laboratories, Inc.

Microwave Spectroscopy with Applications to Chemistry, Nuclear Physics and Frequency Standards. *L. J. Rueger, R. G. Nuckolls, Harold Lyons,* National Bureau of Standards

Recording Atmospheric Index of Refraction at Microwaves. *George Birnbaum, S. J. Kryder, R. R. Larson,* National Bureau of Standards

Measurement of Microwave Field Patterns Using Photographic Techniques. *W. E. Kock,* Bell Telephone Laboratories, Inc.

Friday, January 12

9:30 a.m. Measurement of Power and Attenuation

Presiding: E. W. Houghton, Bell Telephone Laboratories, Inc.

Absolute Microwave Power Measurements. *A. C. Macpherson, D. M. Kerns,* National Bureau of Standards

Broadband Bolometer Development. *W. E. Waller,* Polytechnic Research and Development Company

Calibrating Ammeters above 100 Mc. *H. R. Meahl, C. C. Allen,* General Electric Company

A Microwave Oscillograph. *W. B. Sell, J. V. Lebacqz,* The Johns Hopkins University School of Engineering

Precision Milli-Decibel Waveguide Attenuation Measurements. *J. H. Vogelman,* Watson Laboratories

Dissipative and Piston Attenuator Corrections. *C. M. Allred,* National Bureau of Standards

2:00 p.m. Measurement of Transmission and Reception

Presiding: E. P. Felch, Bell Telephone Laboratories, Inc.

A Field Strength Meter for 600 Megacycles. *J. A. Saxton,* National Physical Laboratory (England)

Measuring Techniques for Broad Band Long Distance Radio Relays. *W. J. Albersheim,* Bell Telephone Laboratories, Inc.

Wide Band Swept Frequency Measurements Applicable to Traveling Wave Tubes. *F. E. Radcliffe,* Bell Telephone Laboratories, Inc.

Microwave Techniques in the 28,000 to 300,000 Megacycle Region. *Leonard Swern,* Sperry Gyroscope Company

Measurement of Characteristics of Crystal Units. *L. F. Koerner,* Bell Telephone Laboratories, Inc.

Reflecting Surface to Simulate an Infinite Conducting Plane. *S. J. Raff,* Naval Ordnance Laboratory

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leted $4,000,000 Ordnance Environment aboratory.

Naval Research Laboratory: The tour will e devoted principally to work on highequency measurements. The Antenna esearch Branch will demonstrate various icrowave antennas. Investigations of the ature of the upper atmosphere by means of ckets will be covered in a movie. There ill be a demonstration of the instruments nd antennas used for measuring extrarrestrial radiation, including a model of 50-foot parabolic antenna.

REGISTRATION AND HOTELS

Registration will be Wednesday, January), at 9:30 a.m. at the Hotel Statler. The gistration fee is $2.50 if paid at the Statler $2.00 if paid in advance by mail. Checks money orders should be made out payable W. F. Snyder, National Bureau of Standds, Washington 25, D. C.

Arrangements have been made with the atler and Hamilton Hotels to hold blocks rooms to within two weeks of the date of e conference. The rates are as follows:

	Double Room	Single Room
otel Statler, 16th and K Streets	$8.00 to 14.50	$5.50 to 11.50
otel Hamilton, 14th and K Streets	7.25 to 8.75	4.75 to 6.25

Reservation requests should be sent directly to the hotel of your choice, making reference to the Conference. If the hotel is already filled the request will be routed to a nearby hotel. Since there are only a limited number of single rooms available, sharing of double rooms will improve your chances of obtaining a reservation.

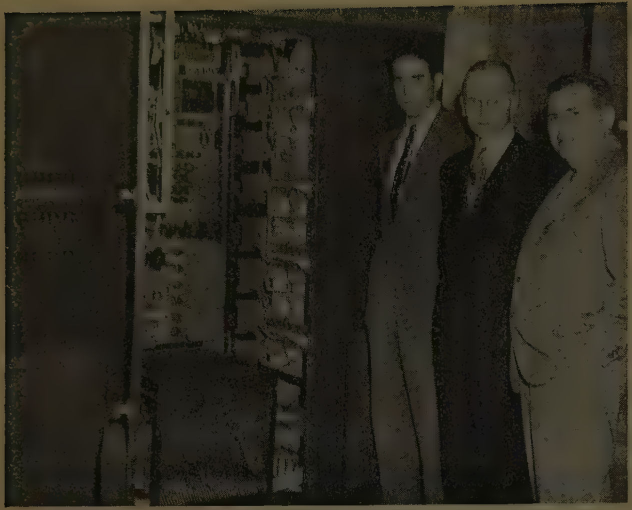
COMMITTEES

The sponsor representatives for the conference are: for AIEE, W. R. Clark; for IRE, Ernst Weber; for NBS, Harold Lyons. Ernst Weber is Chairman and R. V. Lowman is Secretary for the Joint AIEE-IRE Committee on High-Frequency Measurements; Harold Lyons is Chairman of the AIEE Group, and E. I. Green is Chairman of the IRE Group. The other chairmen are: *Technical Program Committee,* F. J. Gaffney; *Publicity,* E. P. Felch; *Local Arrangements,* Harold Lyons. I. G. Easton is Treasurer, and W. F. Snyder is Local Treasurer, of the Finance Committee.

Vice-President Veinott Tours Six Student Branches in Philadelphia Area

The Philadelphia Section, under the leadership of Chairman S. Reid Warren, Jr., is making a bid for more students this year, and as part of this program a 2-day tour to six affiliated Student Branches and also a visit to the Wilmington Subsection was made. On November 6 and 7, C. G. Veinott, Vice-President of District 2 (Middle Eastern) and J. S. Antel, Jr., Chairman of the District 2 Committee on Student Activities, along with various other members of the Philadelphia Section, visited the University of Delaware, Drexel Institute of Technology, University of Pennsylvania, Princeton University, Swarthmore College, and Villanova College, giving talks on how AIEE functions for students and pointing out how participation in Branch and Section activities can help the young engineer in his profession.

Before leaving on the tour, Vice-President Veinott complimented the Section on the fact that Kenneth Fegley, Counselor for the



Shown at the Moore School of Electrical Engineering, University of Pennsylvania, are, left to right: J. S. Antel, Jr., C. G. Veinott, and Dr. C. C. Chambers. In the background is the new electronic digital computer (MASC) being built at the University of Pennsylvania

University of Pennsylvania Student Branch, had been elected District Chairman of Student Activities for 1951–2, and that the next District Student Prize Paper competition would be held at Villanova College in April 1951.

The first campus to be visited was Princeton. Mr. Antel explained to the electrical engineering students how AIEE operates for students, particularly at the District level, and urged them to participate in its activities. Mr. Veinott gave an interesting talk on the engineering career. He said the three things a prospective employer considers are the applicant's scholastic record, extra-curricular activities, particularly leadership in his student branch, and personal qualifications. The student was cautioned to select his first employer with great care, and to watch the first five years in industry when the pattern of his life probably would be set. He was urged to start immediately on a course of orientation and training, to continue advanced study, to become a part of his community, to register as a professional engineer at his first opportunity, to improve his personal characteristics by fearless and conscientious application of self-appraisal methods, and to broaden himself by the right kind of reading. He was further shown how AIEE could be of invaluable help in his development from student days until his death; that the help he could receive was limited only by the extent to which he participated in its activities. *Electrical Engineering* was cited as an indispensable means for keeping up with his chosen profession. He was told about numerous other Institute publications which could help him. Greater benefits could be obtained by attending and participating in the activities of Branches and Sections. Also outlined were the thrills, self-help, and inspiration that could be obtained by serving on national technical committees, and by writing and presenting papers and discussions at national and district meetings.

At Princeton the beautiful new Firestone Library was inspected and a tour of the electrical engineering laboratories was made, ending in the special laboratory for research in ultrasonic phenomena.

The second stop was Wilmington, Del., where a joint meeting of the Wilmington Subsection and the University of Delaware Student Branch took place at Brown Vocational School. Mr. Veinott and Mr. Antel repeated the talks given at Princeton to more than 100 listeners. Featured speaker of the evening was S. G. Rosch, of the Anaconda Wire and Cable Company, who graphically outlined the role of modern chemistry in producing superior synthetic insulations, which, incidentally, had found numerous other useful applications.

The following morning the group saw R. C. Disque, Dean of Drexel Institute, who felt that Philadelphia was the ideal location for a co-operative engineering school such as Drexel because of the widely diversified industry in Philadelphia with no one industry dominating the scene. He told of his friendship with Herman Schneider, founder of the University of Cincinnati, the first co-operative school, and how he had had to finish the task of organizing the Northwestern co-operative school in Evanston, Ill., upon Schneider's death. The group then called upon James Crease, President of Drexel, in his office. He was well aware of the growing shortage of engineering students, and well informed about what was going on at Drexel.

In the afternoon, Mr. Veinott and Mr. Antel addressed a delegation from Drexel and from the University of Pennsylvania Student Branch at the Moore School of Electrical Engineering, University of Pennsylvania. Carl C. Chambers, Acting Dean of the Moore School, conducted the speakers and some members of the Philadelphia Section on a tour through the Moore School, birthplace of the ENIAC and EDVAC, the famous electronic digital computers now at the Aberdeen Proving Ground in Maryland. Using more than 20,000 vacuum tubes, these computers can multiply a 10-digit number by another 10-digit number in 1/360th part of a second. Dean Chambers explained that they are now constructing one of these electronic giant-brain computers for their own use; already finished was the unit that fired 3,000,000 pulses per second at precise intervals to actuate the computer. Other points of interest were the mechanical differential analyzer, capable of performing 14 successive integrations, and the laboratory for research on uses of electricity in medicine.

The group then had a brief interview with Harold E. Stassen, President of the University of Pennsylvania. After the group had complimented him for his address at the AIEE Winter General Meeting in New York in January, and for his Saturday-night reply to President Truman's pre-election speech, the gravity of the current situation in Korea was discussed briefly. Mr. Veinott, quoting Engineers' Council for Professional Development figures, told President Stassen that by 1954 there probably would be only 12,000 engineering graduates to fill a need conservatively estimated at better than 30,000—nearly three jobs for each graduate, if no engineering students were drafted. As many will be drafted, the shortage threatens to be even more serious. President Stassen recalled that the Department of Labor estimates a surplus. Putting his finger on the crux of the situation, President Stassen said that the place to work is on the secondary schools.

Next on the schedule was Swarthmore College, where Mr. Veinott and Mr. Antel repeated their talks, essentially as given at Princeton, to a group of about 40 engineering students from all four classes. Following this, a call was paid on Dean Everett Hunt. Shortage of future engineers was discussed. Dean Hunt related some of his interviews with General Hershey relative to the draft, as a member of a committee of small-college representatives.

At a regularly scheduled meeting of the Villanova College Student Branch, at which about 75 students were in attendance, Mr. Antel and Mr. Veinott gave the listeners the same messages as at Princeton. Following this, a Bell Telephone Company engineer gave an interesting technical talk on the television facilities in the area.

AIEE Board of Directors Holds Regular Meeting in Oklahoma City

The regular meeting of the AIEE Board of Directors was held at the Skirvin Hotel, Oklahoma City, Okla., on October 26, 1950, during the Fall General Meeting of the Institute.

The minutes of the meeting of the Board of Directors held on August 4, 1950, were approved.

The following actions of the Executive Committee on membership applications, upon recommendation of the Board of Examiners, were reported and confirmed: seven applicants transferred and one elected to the grade of Fellow; one Fellow reinstated; 69 applicants transferred and 34 elected to the grade of Member; one Member reinstated; 219 applicants elected to the grade of Associate; 139 Student members enrolled.

Recommendations adopted by the Board of Examiners at meetings on September 21 and October 19, 1950, were reported and approved. Upon recommendation of the Board of Examiners, the following actions were taken: 11 applicants were transferred and one was elected to the grade of Fellow; 83 applicants were transferred and 27 were elected to the grade of Member; 325 appli-

nts were elected to the grade of Associate; 5 Student members were enrolled.

Expenditures were reported by the Finance mmittee and approved by the Board, as lows: August 1950, $65,758.21; Sepnber, $54,332.32; October, $94,731.02.

A budget for the appropriation year 1950–51, prepared by the Finance Committee, s adopted with certain revisions.

The Board considered favorably a proposal at the dues and entrance and transfer fees transferred from the constitution to the laws, and requested the Committee on nstitution and Bylaws to present at the nuary Board meeting formal recommendans regarding the necessary amendments to constitution and bylaws.

Upon recommendation of the Committee Planning and Co-ordination, the following etings were authorized, some previously thorized without specific dates:

uth West District, St. Louis, Mo., April –17, 1952

ll General, New Orleans, La., October –17, 1952

rth Eastern District, Boston, Mass., ril 29–May 1, 1953

cific General, Vancouver, B.C., August –21, 1953

The Board approved in principle the limition of elevation to the grade of Fellow to e method known as proposal by invitation, e invitation to be extended by the Board Directors; and referred the matter to the ard of Examiners and to the Committee on nstitution and Bylaws with a request that commendations be presented at the Januy meeting of the Board.

The Board of Examiners and the Commite on Constitution and Bylaws were reested to present to the Board of Directors, its January meeting if possible, recomendations regarding amendments to the nstitution to include definitions of uniform ades of membership as recommended by e Engineers' Council for Professional evelopment.

Chairman Hooven of the Committee on anning and Co-ordination reported a mmary of votes received from the Institute embers regarding procedure in the election Institute officers. The Board voted to take steps to change the election procedure, d directed Chairman Hooven to report the turns to the membership in *Electrical gineering* (see page 82).

The following amendments to the Instite bylaws were adopted, as recommended the Committee on Constitution and Byws:

Section 33. Amended to read: "To cilitate cooperation among Student anches and Joint Student Branches there all be a Committee on Student Activities each geographical District having three more Branches, consisting of the Vice esident, District Secretary, and the Counors of all Branches and Joint Student anches within the District. Not later than ril 15th the committee shall elect, from nong the Counselors appointed for the next ministrative year beginning August 1st, chairman of the District Committee on ident Activities, and transmit the name of chairman elect to the Vice President and Institute headquarters. The committee y elect such other officers as it deems desirable, particularly a vice-chairman who may succeed to the chairmanship. The chairmen of the District Committees on Student Activities shall be appointed members of the Committee on Student Branches and shall be responsible to the officers of the Institute and to the Committee on Student Branches for the conduct of student affairs in their respective Districts."

Section 51. Amended to read: "Any person registered as a student, undergraduate or graduate, in an engineering curriculum which prepares students for the profession of engineering, and which is fully accredited by the Engineers' Council for Professional Development, where such accrediting applies, may be enrolled as a Student member of the American Institute of Electrical Engineers, provided the student is devoting full time preferably, but in no case less than 30 per cent of full time to studies under the supervision of the institutions in which he is registered. If the curriculum is not fully accredited by Engineers' Council for Professional Development, or in geographical areas where ECPD accrediting does not apply, the Board may waive this requirement on the recommendation of the Committee on Student Branches. A graduate Student whose term of enrollment, as specified in Section 53, has expired may not again enroll as a Student member."

Section 53. The last sentence deleted, and the following substituted in its place: "Student membership shall not in any case extend over a period of more than five years."

Section 60. Amended to read: "Each Student Branch shall have a Counselor, chosen as follows: Not later than March 1st each Branch shall nominate to the Vice President of the District an Institute member chosen from the electrical engineering faculty of the institution at which the Branch is located for appointment as Counselor for the year beginning on August 1st following. If on April 1st any Branch has not submitted its nomination, the Vice President shall make his own selection and notify the Branch and the appointee of his action. The Vice Presidents shall forward all appointments as Counselor to Institute headquarters. The Counselors shall be eligible for reappointment from year to year. The Counselors shall be responsible to the officers of the Institute and to the Student Branch Committee for the conduct of the affairs of their respective Branches. Reports of the proceedings at each Branch meeting shall be made promptly by the secretary of the Branch to the Secretary, the chairman of the Committee on Student Branches and to any other officers as instructed. In the case of a Joint Student Branch, as further referred to in Section 63, a Counselor shall act jointly with the duly appointed Counselors of other national engineering societies in matters affecting the student society and the welfare of its members."

Section 84. Amended to read: "The Committee on Student Branches shall consist of not less than fifteen members, at least one of whom shall be a member of the Board of Directors, five from the membership at large and the chairmen of the District Committees on Student Activities. The committee shall have the general supervision and management of the Student Branches of the Institute. The Committee on Student Branches shall also be concerned with the problems of individual Student members having no Branch affiliation. The committee shall confer with the Branch officers and it shall consider, investigate, and make reports and recommendations to the Board of Directors for action upon all matters regarding or involving the interests and welfare of Branches and Students or the relations between these organizations and the Institute."

It was reported that the Engineers Joint Council had voted, at its meeting on September 15, 1950, to establish an Engineering Manpower Commission, subject to the action of the governing Boards of the member societies, the commission to have the responsibility of "(a) developing policies and procedures designed to secure the most effective use of engineering skills and experience in industry and in government (civilian and

AIEE Southern District Holds Meeting

On October 20, District 4 (Southern) held an executive committee meeting in Atlanta Ga. Left to right, seated, are: F. C. De Weese, J. R. Raney, Professor W. J. Seeley, Russell Ranson, J. D. Harper, P. R. Sprancher. Left to right, standing, are: W. Y. Adair, E. D. Nuttall, Joseph Bronaugh, W. E. Dent, S. A. Ferguson, H. T. Smith, F. G. Hollins, J. W. Wilson, C. V. Booth, H. P. Peters, Professor P. H. Nelson, R. M. Alspaugh, J. M. Flanigen, R. B. Liverman, J. W. Crabtree, M. H. Hollins, N. H. Erlandson, and J. F. Webb

military) during the emergency and (b) taking necessary steps within the scope of EJC to put such policies and procedures into practice." It was reported also that President LeClair had appointed O. W. Eshbach, A. C. Monteith, and H. A. Winne as Institute representatives. The Board voted its approval of the establishment of an Engineering Manpower Commission and of President LeClair's appointment of AIEE representatives.

At the meeting of the Board of Directors on June 15, 1950, the Technical Advisory Committee was authorized "to give final approval, in the name of the Institute, to definitions of activities and definitions of fields of specialization in electrical engineering under preparation for the Office of Naval Research, by the EJC Committee on Survey of Selected Engineering Personnel." It was reported that the definitions as revised and approved by the Technical Advisory Committee had been submitted to the Engineers Joint Council Committee on Survey of Selected Engineering Personnel, and that the Director of the Survey had expressed appreciation of the excellent work done by the Technical Advisory Committee. The Board voted its approval of the definitions submitted by the Technical Advisory Committee.

Members of the Board of Directors were selected to serve as representatives on the Nominating Committee, and as alternates, as follows: Representatives—W. L. Everitt, R. A. Hopkins, J. A. McDonald, Elgin B. Robertson, W. J. Seeley; Alternates—W. J. Barrett, M. D. Hooven.

The Board referred to the Committee on Constitution and Bylaws a recommendation of the Standards Committee that the first paragraph of Section 83 of the bylaws be revised to delete the word "ex-officio" but to retain the clause "and such additional members as may be determined by the plan of organization adopted by the Standards Committee." This recommendation of the Standards Committee resulted from the committee's discussion on the reorganization of the committee to comply with the Board's elimination of ex-officio memberships. It was the conclusion that the committee should consist of an executive committee composed of members appointed by the President and additional members as determined by the plan of organization to be set forth in revised bylaws of the Standards Committee. Representatives of technical committees involved in standardization work would be included. The plan would provide also for the inclusion of chairmen, presidents, and liaison representatives of certain other groups formerly included as ex-officio members.

The Standards Committee reported the appointment of E. B. Paxton to replace John Grotzinger, resigned, as one of the three AIEE representatives on the Electrical Standards Committee of the American Standards Association (ASA).

The Board voted that the Institute vote for the six nominees for the ASA Board of Directors whose names were submitted to the Member-Bodies.

Vice-President Veinott, chairman of the Special Committee to Study Section Growth Awards, presented a brief progress report.

The Board approved a recommendation of the Special Committee on Co-operation with the Institute of Electrical Engineers of Japan that the AIEE reply that it is not in position to solicit funds for the re-establishment of the provisions of the Iwadare Foundation. The Special Committee on Co-operation with the Institute of Electrical Engineers of Japan was discharged with thanks.

Upon recommendation of the Special Committee, the Board voted that members of foreign engineering societies entitled to exchange privileges for three months be permitted to register at AIEE meetings without the payment of any fee.

J. W. Barker and I. Melville Stein were reappointed the AIEE representatives on the Council of the American Association for the Advancement of Science for a term of two years beginning January 1, 1951.

Vice-President Veinott made a brief report on his attendance as representative of President LeClair at the annual dinner of the Engineers' Council for Professional Development (ECPD), held in Cleveland on October 20.

Mr. Hooven, one of the Institute's representatives on ECPD, gave a brief report on the annual meeting of ECPD, held in Cleveland October 20–21, mentioning in particular the plans of the Committee on Professional Training, of which A. C. Monteith is chairman, for a broad program for assisting young engineers during the first five years after graduation. Efforts are being made to secure co-operation among industry, the engineering schools, and the engineering societies. The Institute's share toward the cost of this program was included in the AIEE budget for the year beginning October 1, 1950, contingent upon proportionate contributions by the other societies concerned.

The Board approved a revised "Library Agreement" of the Founder Societies and the United Engineering Trustees, Inc., concerning the Engineering Societies Library.

In response to an invitation issued by President Eisenhower of Columbia University to the Institute to participate in the observance, in 1954, of the 200th anniversary of the establishment of Columbia University as an institution of higher learning, the Board voted that the Institute express interest in the celebration, a desire to be kept informed as plans are developed, and the intention to participate in an appropriate manner.

It was announced that President LeClair had been notified that the bylaws of the Institute of Radio Engineers have been amended making Student dues $5.00 per year, effective January 1, 1951.

Upon recommendation of the Committee on Student Branches, the Board authorized the formation of a Student Branch at the University of Saskatchewan.

Upon report that the electrical engineering curriculum at the University of Massachusetts had been fully accredited by the ECPD, the Board authorized the formation of a Student Branch at that university upon favorable action by the Committee on Student Branches.

The Board voted that members of The Institution of Electrical Engineers (Great Britain) living in the United States and Canada be granted membership privileges with regard to the registration fee at the 1951 Summer General Meeting in Toronto.

Decision was made to hold the next two meetings of the Board of Directors in New York on Thursday, January 25, 1951, during the Winter General Meeting, and in Miami, Florida, on Thursday, April 12, during the Southern District Meeting.

Present at the meeting were: President T. G. LeClair; Past Presidents J. F. Fairman and Everett S. Lee; Vice-Presidents W. C. DuVall, A. H. Frampton, H. R. Fritz, R. A. Hopkins, J. A. McDonald, J. R. North, C. S. Purnell, W. J. Seeley, J. G. Tarboux, C. G. Veinott; Directors W. J. Barrett, E. W. Davis, A. G. Dewars, W. L. Everitt, N. B. Hinson, M. D. Hooven, F. O. McMillan, Elgin B. Robertson, H. J. Scholz; Secretary H. H. Henline.

Questionnaire on Institute Elections Reveals Procedure Is Satisfactory

Very few members of the Institute are interested in its election procedure, but from those who took the trouble to send in the coupon in President LeClair's article in the October issue (*EE, Oct '50, p 855–6*) it can be deduced that the present system of election of officers is satisfactory.

The report of the returns, made by the Committee on Planning and Co-ordination, shows that 204 responses to the article were received as of November 16. Question 1, "Would you recommend that a direct-mail request for nominations be sent to each member at a cost of approximately 15 cents per member, with the understanding that a corresponding service of some other type be omitted?" received only 7 Yes answers, 167 No's. Question 2, "Would you recommend that the primary ballot or request for suggestions be substituted for the present election ballot with the understanding that the action of the Nominating Committee shall be considered final in the absence of a ticket by petition?" received 29 Yes answers, 139 No's.

Probably the most significant statistic, however, is that 88 persons wrote that the present system of electing officers is satisfactory and, since only 13 indicated some degree of dissatisfaction with election procedures, it probably can safely be assumed that the great number of Institute members who did not respond to the request for an expression of their opinion feel that the procedure is a good one. Consequently, the Planning and Co-ordination Committee recommended to the Board of Directors at the Fall General Meeting in Oklahoma City that no change be made in existing election procedures; the Board unanimously approved this recommendation.

Otto Jensen Addresses Milwaukee Section on Mechanical Rectifier

Mr. Otto Jensen, Manager, Rectifier Division of I-T-E Circuit Breaker Company addressed the November meeting of the AIEE Milwaukee Section. His talk was on "The Mechanical Rectifier," his experience

obtaining the rectifier for this country, nd several installations here.

The mechanical rectifier was originally de-eloped in Germany by the Siemens-chuckert Company. After the war, an in-estigation by the Department of Commerce f German industry made the German ex-erience available to all American manufac-irers, and the I-T-E Company decided to nter the rectifier field with the mechanical ectifier. On February 8, 1949, an installa-on consisting of two 3,500-ampere 280-volt -c units was placed in operation at the plant f the Buffalo Electro-Chemical Company, uffalo, N. Y. A second installation consist-ng of two 5,000-ampere 100-volt d-c units vas made at the Canadian Resins and Chem-cals, Ltd., plant in Shawinigan Falls, Quebec, Canada.

Mr. Jensen said that the mechanical recti-er in many respects operates like the mer-ury-arc rectifier, but metallic contacts, syn-hronously driven, are utilized for conducting nstead of an electronic stream. He ex-lained in detail the functioning of the me-hanical rectifier, how it is employed, and the ase of maintenance.

950 AIEE Edison Medal Awarded to O. B. Blackwell

The 1950 Edison medal of the AIEE has een awarded by the Edison Medal Com-nittee to Otto B. Blackwell, Assistant Vice-President (retired) of the American Tele-hone and Telegraph Company (AT&T) for his pioneer contributions to the art of elephone transmission," and will be pre-ented to him at the AIEE Winter General Meeting.

Mr. Blackwell has had a long and dis-inguished career in the Bell Telephone ystem, beginning 44 years ago in the Trans-nission and Protection Division of the AT&T Engineering Department at its Boston headquarters. Subsequently, he vas made head of Dr. Jewett's former de-artment and had supervisory responsibility or transmission development and engineer-ng for protection and inductive interference revention. When the AT&T Department f Development and Research was organized n 1919, he became Transmission Develop-nent Engineer.

In 1934 the Development and Research Department was consolidated with the Bell Telephone Laboratories with Mr. Blackwell as its Director of Transmission Development. The following year he was ppointed Manager of Staff Departments, etaining supervisory responsibility for trans-nission and protection developments. In 937, he became Vice-President in charge f all of the technical departments, including Research, Apparatus, and Systems, in addi-ion to Transmission and Protection. Early n 1940, he was made responsible as Vice-President for all of the nontechnical depart-nents including Patent, Personnel, Legal, nd Publication, and the Staff Departments reviously referred to. Simultaneously, he ave up supervisory responsibility for the echnical departments. Following the re-irement of Dr. Jewett late in 1944, Mr. Blackwell returned to the AT&T as an Assistant Vice-President and also became member of the Bell Telephone Labora-ories' Board of Directors.

The medalist has made many important personal contributions to the advancement of the art. One of his early works was the quadded toll cables, notably the apparatus and technique for measuring capacitance unbalances and the so-called capacitance-unbalance test-splice procedure used in installing cables. In the evolution of the "4-wire" type of (repeater) circuit, he was the first to recognize that its most advan-tageous field of use would be on long-loaded 19-gauge toll cables. A total of 22 patents (including eight joint patents) testify to his valuable inventive efforts. A brief biog-raphy will appear in the AIEE Personalities columns of the February issue.

AIEE Southern District Meeting to Be Held in Miami April 11–13

A 3-day meeting of the AIEE Southern District will be held in Miami Beach and Miami, Fla., April 11–13, 1951. Head-quarters will be at the MacFadden-Deauville Hotel. The general committee under the chairmanship of Harvey F. Pierce is hard at work arranging a fine program.

This is an opportunity not only to attend the Southern District Meeting but also to spend your 1951 vacation in one of the coun-try's famous vacation lands. Miami Beach, with its 370 hotels, stands at the top of the list of Florida's resort cities. Built on some 30 islands with eight miles of sandy beach along the Atlantic Ocean, Miami Beach is devoted solely to rest and recreation. The city neither has nor seeks industrial plants or actories. Neither has it a railroad nor an airport. Miami Beach is located in a nat-urally air-conditioned spot; through the summer the southeastern tradewinds furnish an almost constant breeze, while the sur-rounding waters of the Atlantic Ocean and of Biscayne Bay cool the air by absorbing the heat. In winter the adjacent waters return their heat to the atmosphere, keeping the cli-mate mild.

View of Miami Beach, where AIEE will convene April 11–13 for the Southern District Meeting

Chairmen for the Southern District are: H. F. Pierce, *General Chairman;* C. K. Lingo, *Publicity and Attendance;* O. T. Ayers, Jr., *Hotels and Registration;* Dr. H. H. Sheldon, *Technical Papers;* J. W. Lacy, Jr., *Program;* E. F. Johnson, *Finance;* J. W. Bevelle, *Transportation and Inspection Trips;* C. W. Cogburn, *Sports and Entertainment.*

Fortescue Fellowship Applicants Must File by February 15

Candidates for the Charles LeGeyt For-tescue Fellowships should file applications on the form provided by AIEE so that they reach the Secretary of the Fellowship Committee by February 15, 1951. Awards will be made not later than April 1. Copies of the applica-tion forms are available at accredited colleges or at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

The Charles LeGeyt Fortescue Fellowship, sponsored by AIEE, was established in 1939 as a memorial to Charles Fortescue in recog-nition of his valuable contribution to the electric power industry. To this end the Westinghouse Electric Corporation, with which Doctor Fortescue was associated throughout his professional career, set up a trust fund of $25,000 to provide graduate fellowships in electrical engineering.

The successful candidates, selected by the AIEE committee which administers the fund, receive a minimum allowance of $500, and additional allowance may be granted at the discretion of the committee.

It is intended that candidates shall pursue their studies at accredited engineering schools and engage in research problems meeting the approval of the Fellowship Committee. To be eligible, the student must have received a bachelor's degree from an accredited college by the time his work under the fellowship would begin, provided he does not hold or subsequently receive any other fellowship which carries a stipend greater than the tuition required by the institution at which the graduate work is to be under-taken.

District 2 Student Activities Committee Meeting Held

The George Washington University Student Branch was host to the meeting of the Middle Eastern District Student Activi-ties Committee in Washington, D. C., November 3 and 4. The total registration was over 100, with the meeting attended by the 25 schools in the District area and with representatives from 24 schools registered. Present at the meeting were Vice-President C. G. Veinott, representing District 2, and the District Secretary, W. A. Dynes.

Two conferences were held the first morning, one for the Counselors, led by the Chairman of the committee, J. S. Antel, Jr., and one for the Student Branch Chair-men and interested student members, led by the Chairman of the George Washington University Branch, Lynn Garrison. On the afternoon of November 3 there was an inspection trip through the National Bureau of Standards. At a dinner held in the

The counselors and students who attended the District 2 Student Activities Committee Meeting are shown in front of the Administration Building of the George Washington University, Washington, D. C.

evening, Dr. Eugene Crittenden, Senior Associate Director of the National Bureau of Standards, spoke on "Engineering in Government Agencies." He explained the function of engineers in various governmental agencies and gave some suggestions on how to become associated with the government in an engineering capacity. A joint Student-Counselor meeting was held Saturday morning, at which the conclusions of the previous day's meetings were discussed.

Black Hills Subsection of AIEE Denver Section Established

After several years of careful study and promotion, a new subsection of the AIEE Denver Section was established in Rapid City, S. Dak., which is to be known as the Black Hills Subsection. The petition of application was signed by 14 men on September 30, 1950, and approved by the Denver Section Executive Committee on October 6.

On October 6, in the Auditorium of the Black Hills Power and Light Company, the Black Hills Subsection was formally installed and accepted by Mr. W. C. DuVall, Vice-President of District 6 and a member of the Denver Section, who gave a very inspiring talk. J. O. Kammerman, Professor of Electrical Engineering in the South Dakota School of Mines, was elected Chairman of the new subsection, and Robert G. Asheim, Black Hills Power and Light Company, was elected Secretary.

Great Lakes District Holds Executive Committee Meeting

A meeting of the Executive Committee of the AIEE Great Lakes District (District 5) was held October 20, 1950, in the lounge of the Electric Club, Civic Opera Building, Chicago, Ill. The meeting was presided over by Vice-President J. R. North.

Professor D. D. Ewing of Purdue University was selected as the candidate for National Director for the 3-year term beginning August 1, 1951. G. M. Chute was elected District 5 Treasurer for a period of one year. J. C. Woods was selected as member of the National Nominating Committee from the Great Lakes District. The following four members were elected to serve on the Co-ordinating Committee of District 5: E. L. Michelson, Chicago Section; R. E. Trovinger, Fort Wayne Section; C. O. Moyer, South Bend Section; and R. P. Pfeiffer, Illinois Valley Section.

Reports were given on membership of sections, formation of subsections, and public relations activities. AIEE President T. G. LeClair spoke to the meeting on a recent change in policy whereby the various Vice-Presidents are given the responsibility of making visits to the Sections and Subsections. The meeting was then thrown open for questions. The balance of the meeting was given over to reports of activities of various Sections, and to a discussion of student prize papers. It was decided that each Section within the Great Lakes District should contribute $3.00 per year to the District treasury to be used to provide District prizes of $25.00 and $15.00 for the graduate student paper competition, and also to take $25.00 each year from the District 5 treasury to provide a first prize of $15.00 and a second prize of $10.00 for undergraduate student papers.

It was noted that most of the smaller Sections hold an annual meeting for business and election of officers, but that the attendance at such meetings is notoriously poor. Larger sections conduct their elections by mail, obtaining wider participation from their membership, and releasing another evening for technical purposes.

1950 Year Book Issued. The 1950 edition of the AIEE Year Book has been issued in accordance with 1949–50 budget provisions. Addresses are corrected as of July 1, 1950. Copies have been distributed to all national, District, and Section officers, Student Branch counselors, and all members of national committees. Fellows, Members, and Associates may obtain copies by writing to AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. The Year Book is not available to nonmembers of AIEE; nor is its use permitted for commercial, promotional, or circularization purposes.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Division

Committee on Wire Communications Systems. (*L. G. Abraham, Chairman; G. B. Ransom, Vice-Chairman; P. G. Edwards, Secretary.*) This committee held meetings on February 1, June 14, and October 23, and plans a meeting at the Winter General Meeting in New York. Because of the wide geographical spacing of the members of this committee, it is hoped to hold committee meetings at all General Meetings whenever a reasonable number of members can be expected to attend.

This committee has sponsored papers at all General Meetings held during the past year and plans two sessions at the next Winter General Meeting. Papers are already scheduled for later meetings during 1951. The committee has co-operated with various Section Meeting Committee Chairmen in helping plan technical programs at Section Meetings.

At present there is no active work under way on Standards, though several subjects for possible Standards are under consideration.

General Applications Division

Committee on Land Transportation. (*H. F. Brown, Chairman; L. W. Birch, Vice-Chairman; R. L. Kimball, Secretary.*) Interesting developments, which have been closely followed by the Committee, continue to appear in the field of electric traction. Last spring, through the courtesy of the Pennsylvania Railroad, two outstanding new multiple-unit suburban cars were inspected; one a rectifier car taking a-c trolley energy, converting to direct current by means of a mercury-arc rectifier to supply two d-c traction motors; the other equipped with four high-speed, high-reduction, truck-mounted a-c motors similar in mechanical arrangement to modern rapid transit equipments.

The New York Central and another traction development have brought air-conditioned riding to commuters on new thoroughly modern multiple-unit cars recently placed in service. Additions to its fleet of commuter equipment are being made by the Pennsylvania Railroad and the Reading Company.

Programs, to be announced shortly, are being organized for the Winter General Meeting and subsequent sessions, which will present the highlights of this continued progress and the equally interesting developments in the light traction field.

Industry Division

Subcommittee on Bibliography of Committee on Industrial Control. (*R. W. Jones, Chairman.*) This subcommittee has

pleted a Bibliography on Industrial Con-
. Copies are available at AIEE Head-
rters at a price of $1.25 to members and
0 to nonmembers. The bibliography
tains references to all original papers and
cles of lasting importance which have
n published on the design and applica-
of industrial controllers. Also included
articles and papers dealing with motor
avior under the influence of controllers.
rief résumé of the contents of each article
iven.

he subcommittee is continuing to review
rent literature being published on indus-
l control subjects. If experience shows
t there is sufficient interest in the subject,
bibliography will be reprinted and
ught up to date from time to time.

Power Division

nmittee on Insulated Conductors. (*rman Halperin, Chairman; V. A. Sheals, e-Chairman; C. T. Hatcher, Secretary.*) is committee continues to actively carry its new and enlarged scope of projects ating to insulated wires and cables. out 70 members and special members ended the meetings of the subcommittees l committee in New York on November 1950. The second meeting of this ad- nistrative year will be for two days, and l be held in the middle west in April 1951.

With the increase in kinds of subjects re- ed to insulated conductors that the AIEE v is studying through this committee, as npared to the limited scope of such activi- a few years ago, another result has been increase in the number of sessions at AIEE etings related to insulated conductors. e committee sponsored one session of regu- papers at the Fall General Meeting, and tentative schedule of prospective papers ls for a session at each of the next several ional AIEE meetings. In addition, a nference on polyethylene insulation and a nference on power and control cables in tions and substations are tentatively sched- d during the next year.

Included in the projects of the committee investigations involving a number of di- sified groups in this country. One study n limiters and the related ability of differ- types of insulation to withstand various rt-circuit current duties; another investi- ion covers the standardization of methods making short-time tests on lead and lead- oy sheaths; while a third study covers 60- le impulse and d-c dielectric strength char- eristics of potheads. Problems relating utilization-wiring systems also are receiv- attention.

cience and Electronics Division

mmittee on Metallic Rectifiers. (*I. R. th, Chairman; W. F. Bonner, Vice-Chairman; A. Harty, Secretary.*) A symposium on tallic rectifiers for the 1951 Summer Gen- l Meeting is being organized. The chnical Information Subcommittee has n working on problems in connection with acity loading of metallic rectifiers. The bcommittee on Patents has issued two re- d lists since the December 1949 meeting. e Subcommittee on Standards is currently king on proposed test methods for metal- ectifiers. Over 300 copies of these Stand- s have been distributed since the first of the year and favorable comments have been received from a large number of the AIEE membership. The main committee plans an all-day meeting during the Winter General Meeting to discuss the work of its various subcommittees.

Committee on Electronic Power Converters. (*C. C. Herskind, Chairman; W. N. Farquhar, Vice-Chairman; C. R. Marcum, Secretary.*) The program of this committee was reviewed at a meeting of the Administrative Subcommittee held in New York on October 16. Tentative plans include sessions at the Winter, Summer, and Pacific General Meetings in 1951.

Active projects under way are: 1. The report on "Inductive Co-ordination Aspects of D-C End of Rectifier Installation," being prepared by a working group of the Application Subcommittee, is nearing completion and is expected to be ready for presentation at the Summer General Meeting. 2. A report on the "Basis for Dielectric Tests" has been circulated to the Application, Circuits, and Hot Cathode Subcommittees for review. 3. A group will be appointed to prepare a report on "Practices for Cooling and Corrosion Protection of Rectifiers."

The Hot Cathode Subcommittee is actively engaged in the preparation of standards for "Hot Cathode Power Converters."

AIEE PERSONALITIES.....

I. S. Coggeshall (M '37, F '48), general traffic manager, International Communications Department, Western Union Telegraph Company, New York, N. Y., has been elected President of the Institute of Radio Engineers (IRE) for 1951. Mr. Coggeshall attended Worcestor (Mass.) Polytechnic Institute, and in 1917 became associated with Western Union Telegraph Company. After successive promotions he became general cable supervisor in 1936, and ten years later Mr. Coggeshall was appointed general traffic manager. He is noted for his activity in the adoption of electronic methods and devices in the telegraph and submarine field. For the past 14 years he has specialized in ocean cables, and in World War II he served on the cable committee of the Board of War Communications. He has served actively on the following AIEE committees: Technical Program (1945–46, 49–50); Standards (1949–50); Communications, Co-ordinating Division (1949–50). He is currently Chairman of the Telegraph Systems Committee.

I. S. Coggeshall

Directors elected by the IRE for 1951 are: **G. R. Town** (A '28, M '37), professor of electrical engineering and associate director, engineering experiment station, Iowa State College, Ames, Iowa; **H. F. Dart** (A '20, M '26), manager, Electronics Department, Westinghouse Electric Corporation, Bloomfield, N. J.; **P. L. Hoover** (A '24, M '39, F '44), Head, Department of Electrical Engineering, Case Institute of Technology, Cleveland, Ohio. Mr. Dart has served on the AIEE Electronics Committee (1948–49). Mr. Hoover has served the AIEE on the Student Branches (1942–43, 47–49) and Electronics (1943–44) Committees.

C. S. Purnell (A '29, M '35), supervisor, General Industry, Industrial Sales Department, Westinghouse Electric Corporation, New York, N. Y., has been appointed as eastern district manager of the Agency and Construction Division, Westinghouse Electric Corporation, New York, N. Y. This agency, formed by the amalgamation of the previous Agency and Specialty Division and the Construction Section of the Industrial Division, will handle sales of Westinghouse products through agent, industrial, and wholesale distributors, as well as caring for the needs of the construction industry. Mr. Purnell has been with Westinghouse since 1922, when he joined the company following his graduation from Washington College. He was made a transportation salesman in the New York office in 1927, and an Industrial Division salesman in 1937. Since 1946, Mr. Purnell has been eastern district supervisor of the General Industry Section of the Industrial Division. Mr. Purnell is Vice-President of the New York City District (Number 3) of the AIEE. He served on the following AIEE committees: Finance; Sections; Edison Medal.

C. S. Purnell

B. R. Teare, Jr. (A '29, M '36, F '42), Head, Electrical Engineering Department, Carnegie Institute of Technology, Pittsburgh, Pa., has

been appointed Dean of Graduate Studies. Dr. Teare was born in Menomonie, Wis., on January 12, 1907. He received his Bachelor of Science degree and his Master of Science degree from the University of Wisconsin in 1927 and 1928 respectively. In 1937 he received his Doctor of Engineering degree from Yale University, New Haven, Conn., where he had taught while studying for his advanced degree. In 1939 Dr. Teare joined the faculty of the Carnegie Institute of Technology as Professor of Engineering and was named Buhl Professor in 1943. As such, he is responsible for the establishment and organization of a graduate program in the Electrical Engineering Department. He will retain this post and that of Head of the Department along with his new duties as Dean. Dr. Teare is currently serving the AIEE as Chairman of the Section Membership Committee (Pittsburgh). Other committees he has served on include: Communications; Electrical Machinery; Education; Technical Program; Publication; and Professional Group Co-ordinating Committee. Dr. Teare is also a member of the American Society for Engineering Education of which he is Chairman of the Graduate Study Division, Institute of Radio Engineers, and Sigma Xi.

J. W. Kehoe (A '35, M '47), division staff supervisor, Headquarters Manufacturing Engineering Department, Westinghouse Electric Corporation, East Pittsburgh, Pa., is the winner of the $750 first prize for the best paper from an industrial source in the contest sponsored by the Resistance Welder Manufacturers' Association through the American Welding Society. The winning paper is entitled "A Practical Method for Obtaining Consistent Resistance Welds." Mr. Kehoe is Chairman of the Metal Joining Committee of the Westinghouse Electric Corporation and is also a member of the American Welding Society. The Second Prize of $250 was awarded to **W. B. Kouvenhoven** (A '06, M '22, F '34, Member for Life), Dean and Professor, School of Engineering, The Johns Hopkins University, Baltimore, Md., and **W. T. Sackett, Jr.** (A '48), Batelle Memorial Institute, Columbus, Ohio, for their paper entitled "Electrical Resistance Offered to Non-Uniform Current Flow." Dr. Kouvenhoven is serving the Institute on the following committees: National Fire Waste Council; Safety (Chairman); Principles of Professional Conduct; Division of Engineering and Industrial Research. He is also a member of the American Welding Society and the American Society for Testing Materials. Dr. Sackett is a member of Tau Beta Pi and Sigma Xi.

G. S. Brown (A '33, F '50), professor of electrical engineering, Massachusetts Institute of Technology, Cambridge, Mass., has been appointed associate head of the Department of Electrical Engineering. Dr. Brown will also continue with his duties as director of the Servomechanisms Laboratory. A native of Australia, Professor Brown was educated at the Massachusetts Institute of Technology (MIT), receiving the degree of Bachelor of Science in 1931, his Master's degree in 1934, and his doctorate in 1938. He joined the staff of MIT as a research assistant in 1931 and after successive promotions became professor of electrical engineering in 1946. Dr. Brown has served on the following AIEE committees: Industrial Control; Prizes, Award of; Standards; Industry Co-ordinating; Technical Program; Instruments and Measurements; Industrial Control; Feedback Control Systems (Chairman 49–50).

R. L. Biesele, Jr. (A '45, M '48), Chairman and Professor, Electrical Engineering Department, Southern Methodist University, Dallas, Tex., and **R. G. Slauer** (A '41, M '48), manager, Applications Laboratory, Sylvania Electric Products, Inc., Salem, Mass., will read their own technical papers before the annual session of the International Commission on Illumination to be held from June 25 to July 4, 1951, in Stockholm, Sweden. "Daylight In Classrooms" is the title of the paper to be presented by Professor Biesele. Mr. Slauer's paper is entitled "Space Concepts of Lighting." Both men have been active on Institute committees. Professor Biesele has worked on the Education Committee (1949–51), and is Section Chairman (North Texas). Mr. Slauer served on the Production and Applications of Light Committee (1946–50).

H. R. Searing (A '20, M '25, F '30), President of Consolidated Edison Company of New York, N. Y., Inc., has been elected trustee of The Cooper Union for the Advancement of Science and Art. Mr. Searing was graduated from Cooper Union in 1916 with a Bachelor of Science degree in electrical engineering. He began his career with New York Edison Company, a predecessor of Consolidated Edison, and after successive promotions he became general distribution manager in 1933. He was elected Executive Vice-President of Consolidated Edison in 1944 and five years later became President. He is a trustee or director of all Consolidated Edison subsidiary companies and serves as Chairman of the Board of Consolidated Telegraph and Electrical Subway Company. Mr. Searing has served the Institute on the following committees: Standards; Safety Codes; and Transmission and Distribution. He is also a member of Tau Beta Pi.

J. P. Growdon (A '12, M '20, Member for Life), chief hydraulic engineer, Aluminum Company of America, Pittsburgh, Pa., has been awarded the Legion of Merit by the Department of the Army for meritorious conduct in the performance of outstanding services during World War II. Colonel Growdon, a veteran of both World Wars, served with the Army Service Forces in the European theatre of operations. He joined the Aluminum Company of America in 1925 and was appointed chief hydraulic engineer for the company in 1938. Colonel Growdon has directed the design and construction of most of the large hydroelectric dams built by the Aluminum Company to furnish power for its plants. He is a member of the American Military Engineers and the American Society of Civil Engineers.

J. W. McNall (A '38, M '47), research section engineer, Lamp Division, Westinghouse Electric Corporation, Bloomfield, N. J., has been appointed division engineer of the research department. Dr. McNall was graduated from Case Institute of Technology with a Bachelor of Science degree in physics. In 1936 he joined Westinghouse as a student engineer, and worked in the electronics section of the company's East Pittsburgh, Pa., Research Laboratories. In 1940 Dr. McNall was awarded the B. J. Lamme Scholarship, and under this grant he did graduate work at the Massachusetts Institute of Technology, receiving his Doctor of Philosophy degree in physics in 1942. Since 1946 Dr. McNall has been in charge of the emission section of the research department at the plant in Bloomfield, N. J.

W. F. Hess (A '32, M '41, F '48), Head, Metallurgical Engineering Department, Rensselaer Polytechnic Institute, Troy, N. Y., has been awarded the Samuel Wylie Miller Memorial Medal by the American Welding Society for his contributions to the advancement of welding and cutting of metals. Dr. Hess has been associated with Rensselaer Polytechnic Institute since 1928. He is the recipient of several other awards, among which are the 1944 Lincoln Gold Medal of the American Welding Society, the 1945 American Iron and Steel Institute Medal, and the 1948 John Price Wetherill Medal of the Franklin Institute. Dr. Hess served the AIEE on the Electric Welding Committee from 1940–41 and from 1944–48. He is also a member of the American Institute of Mining and Metallurgical Engineers, American Welding Society, and the Franklin Institute.

R. T. Stafford (A '18, M '18, F '47, Member for Life), assistant to the Executive Vice-President, Allis-Chalmers Manufacturing Company, New York, N. Y., has retired. He was born May 17, 1879, in Buffalo, N. Y., and attended the Bliss School of Engineering. Mr. Stafford began his career with Allis-Chalmers in 1905, and in 1928 he became assistant manager of the Electrical Department in charge of sales and engineering at the Pittsburgh Works. He served there until 1947, when he was named assistant to the Executive Vice-President with headquarters in New York. In 1949, Mr. Stafford was awarded the 50-year Certificate by the National Electrical Manufacturers Association for having completed a half-century of service in the electrical industry.

E. R. Whitehead (A '30, M '39, F '45), Director, Electrical Engineering Department, Illinois Institute of Technology, Chicago, Ill., has been reappointed to the Illinois Professional Engineers Examining Committee for a 3-year term. He has served as a member of the committee for the past two years. Dr. Whitehead joined the Illinois Institute of Technology staff in 1946 as research professor of electrical engineering, and was named director of the department in 1947. Dr. Whitehead is now serving the AIEE on the Committee on Registration of Engineers.

F. J. Gaffney (A '37), chief engineer and manager of operations, Polytechnic Research and Development Company, Inc., Brooklyn, N. Y., has been appointed general manager. Mr. Gaffney had previously been associated

vith Browning Laboratories, Winchester, Mass., and with the National Company, Malden, Mass. Mr. Gaffney is currently serving the Institute on the Instruments and Measurements Committee.

OBITUARY • • • • • •

William McClellan (A '04, M '09, F '12, Member for Life), retired and a past President of AIEE, died November 14, 1950. He was born in Philadelphia, Pa., on November 5, 1872, and was graduated from the University of Pennsylvania with a Bachelor of Science degree in 1900. In 1903 he received his doctorate and taught in the department of physics at the University of Pennsylvania until 1905. Dr. McClellan continued his connection with the University as dean of the Wharton School from 1916 to 1919, and later as a trustee. Between 1919 and 1921 he was Vice-President of the Cleveland (Ohio) Electrical Illuminating Company, after which he became a member of the firm of McClellan and Junkersfeld. In 1929 he was elected Vice-President of Stone and Webster Engineering Corporation, and in 1934 he became President of the Potomac Electric Power Company of Washington, D. C. He was also former President of the Union Electric Company of Missouri. Dr. McClellan served the Institute as Manager from 1912–15, as Vice-President from 1915–17, and as President from 1921–22. Some of the AIEE committees on which he served are: Edison Medal (1913–17, 22–24); Educational (1916–17); Executive (1914–17, 21–24); Public Policy (1914–17, 19–24, 27–28, 32–34); Institute Policy (1935); Publication (1922–23); Power Generation (1927–28); Hoover Medal Board of Award (1937–43), and Traction and Transportation (1916–17).

Burt T. Anderson (A '35), Transportation Research Director, Sales Department, Union Switch and Signal Company, Swissvale, Pa., died November 8, 1950. Mr. Anderson was born in Alexis, Ill., on October 31, 1884, and was graduated from the University of Illinois in 1907 with a Bachelor of Science degree in electrical engineering. Mr. Anderson began his career with the Union Switch and Signal Company in 1907, and returned to it in 1927 after service in various capacities with the Atchison, Topeka and Santa Fe Railway Company, the Delaware, Lackawanna and Western Railroad Company, and the Chesapeake and Ohio Railway. Mr. Anderson returned to the Union Switch and Signal Company in 1927, as assistant to the Vice-President and General Manager. After successive promotions he was appointed director of Transportation Research in 1940. Mr. Anderson was also a member of the American Railway Engineering Association, American Association of Railroad Superintendents, and the Institution of Railway Engineers (London). He served the Institute on the General Industry Applications Committee from 1947–51.

Waldo Arnold Layman (A '99, M '00, F '12, Member for Life), retired, died October 25, 1950. Mr. Layman was born on October 27, 1869, in Smithton, Mo., and was graduated from Rose Polytechnic Institute in 1892. The same year he entered the service of the Wagner Electric Manufacturing Company, which was then an infant industry, and six years later became general manager of the company. During Mr. Layman's employ the Wagner Electric Manufacturing Company grew from 200 employees to approximately 4,000 when he retired as President and Chairman of the Board. Mr. Layman was also an associate member of the British Institution of Electrical Engineers.

Lawrence C. F. Horle (A '20, M '22, F '35), consulting engineer, Newark, N. J., died on October 28, 1950. Mr. Horle was born on May 27, 1892, in Newark, N. J. He received the degree of Mechanical Engineer in 1914 from Stevens Institute, Hoboken, N. J., after which he taught in the Department of Physics at Stevens. From 1917 to 1920 Mr. Horle was Civilian Chief of the Radio Laboratory, Navy Yard, Washington, D. C. He was also associated with the Federal Telephone and Telegraph Company as chief engineer, and with the Federal Telephone Manufacturing Corporation as Vice-President. Mr. Horle was a Fellow of the Institute of Radio Engineers.

Frederick W. Hotchkiss (A '20, M '27), Secretary-Treasurer, Electric Machinery Manufacturing Company, Minneapolis, Minn., died on November 11, 1950. Mr. Hotchkiss was born in Bladen, Neb., on June 3, 1894. He received his Bachelor of Science degree in electrical engineering in 1918 from the University of Minnesota, and immediately after graduation he became associated with the Electric Machinery Manufacturing Company. He served first as Sales Engineer and in 1930 he was appointed Treasurer and later Secretary of the Company. Mr. Hotchkiss served as Secretary-Treasurer of the Minnesota Section of the AIEE.

Ervin Moul Fitz (A '03, Member for Life), retired, died on July 6, 1950. Mr. Fitz was born on March 31, 1872, in Hanover, Pa. His experience included association with the Richmond Locomotive Works, the Southern Railway, Schenectady Locomotive Works, and the Chesapeake and Ohio Railway. In 1900 he entered the employ of the Pennsylvania Railroad as an electrical engineer and served the company until his retirement a few years ago.

MEMBERSHIP • • • •

Recommended for Transfer

The board of examiners at its meeting of November 16, 1950, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Fellow

Balsbaugh, J. C., consulting engr., 238 Main St., Cambridge, Mass.
Brownlee, W. R., supervisor, power systems engg., Commonwealth Associates, Inc., Jackson, Mich.
Davenport, J. A., elec. & mech. advisor, Corps of Engineers, Cincinnati, Ohio
Ranger, R. H., pres., Rangertone, Inc., Newark, N. J.

4 to grade of Fellow

To Grade of Member

Appell, W. M., outside plant engr., Southwestern Bell Tel. Co., Little Rock, Ark.
Blade, E., asst. prof. of elec. engg., The City College of New York, N. Y.
Charlton, R. D., engr., General Electric Co., Erie, Pa.
Clarkson, W. G., engr., Canadian Westinghouse Co., Ltd., Hamilton, Ontario, Canada
Crow, E. A., Jr., senior design engr., Fairchild Engine & Airplane Corp., Oak Ridge, Tenn.
Dunn, O. E., Jr., elec. engg. instructor, University of Dayton, Dayton, Ohio
Field, E. J., distribution engr., Railway & Industrial Engineering Co., Greensburg, Pa.
Fraser, E. G., district engr., Canada Wire & Cable Co., Ltd., Montreal, Quebec, Canada
Gentle, E. C., Jr., district trans. supervisor, Southern Bell Tel. & Tel. Co., Mobile, Ala.
Gierisch, W. C., chief elec. engr., Houston Lighting & Power Co., Houston, Tex.
Guy, J. D. C., Jr., sales engr., General Electric Co., Waterbury, Conn.
Hall, T. H., asst. supt., Tide Water Power Co., Wilmington, N. C.
Hansen, E. F., elec. engr., General Electric Co., West Lynn, Mass.
Hemman, R. J. E., assoc. prof. of engg. research, Pennsylvania State College, State College, Pa.
Lehrkind, A., elec. engr., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Mathis, H. F., assoc. prof. of elec. engg., University of Oklahoma, Norman, Okla.
Mazumdar, B. C., deputy director, Ministry of Industry & Supply, New Delhi, India
Meigs, J. R., assoc. prof. of elec. engg., University of Southern California, Los Angeles, Calif.
Neikirk, R. S., engr., Rural Electrification Administration, Washington, D. C.
Newton, G. C., Jr., asst. prof. of elec. engg., Massachusetts Institute of Technology, Cambridge, Mass.
Peebles, J. E., application engr., General Electric Co., Schenectady, N. Y.
Rhodes, M. D., mgr., Warren Electric Cooperative, Inc., Youngsville, Pa.
Rohlfs, A. F., asst. to engr., high voltage lab., General Electric Co., Pittsfield, Mass.
Spitzer, C. F., asst. prof. of elec. engg., Yale University, New Haven, Conn.
Tanner, A. R., mgr., Sacramento Office, General Electric Co., Sacramento, Calif.
Temple, R. B., engr., General Electric Co., Portland, Oreg.
Turner, W. O., pres. & genl. mgr., Louisiana Power & Light Co., New Orleans, La.
Wise, A., elec. engr., Brookhaven National Laboratory, Upton, N. Y.

28 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before January 25, 1951, or March 25, 1951, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Bouma, S., Venezuelan Oil Concessions, Las Piedras, Venezuela, S. A.
Burrough, E. L., Boeing Airplane Co., Seattle, Wash.
Carroll, H. F., Pennsylvania Power & Light Co., Allentown, Pa.
Clements, H. E., James R. Kearney Corp., St. Louis, Mo.
DeBaene, E. C., Detroit Edison Co., Detroit, Mich.
Dufour, G. M., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Gamble, C. B., Cary B. Gamble & Associates (Partner), New Orleans, La.
Hussain, F., Punjab P.W.D., Electricity Branch, Shahdara Bagh, W. Pakistan
Johnson, B. W., Mead & Hunt, Inc., Madison, Wis.
Jones, A. B., London Electricity Board, London, England
Leightner, D. B., Commonwealth Elec. Corp., Welland, Ontario, Canada
LeVois, H. C., Gulf States Utilities Co., Beaumont, Tex.
McEntire, K. T., General Elec. Co., Detroit, Mich.
Newman, H. L., University of Buffalo, Buffalo, N. Y.
Presley, E. E. (re-election), Robt. E. Foley Construction Corp., Binghamton, N. Y.
Robar, A. S., British Columbia Elec. Railway Co., Ltd., Vancouver, B. C., Canada
Rogers, H. S., Burns & Roe Inc., New York, N. Y.
Savage, J. A., Southern Methodist University, Dallas, Tex.
Sawin, D. B., Jackson & Moreland, Boston, Mass.
Sharan, S., Bihar College of Engineering, Patna, India
Teale, G. F., University of California, Berkeley, Calif.
Vendrick, J. H., General Elec. Co., Amarillo, Tex.
Wade, H. R., Kansas City Power & Light Co., Kansas City, Kans.
Warner, C. D., P. O. Box 281, Fort Scott, Kans.

24 to grade of Member

OF CURRENT INTEREST

New Figure Set for the Speed of Light by Stanford University Physicists

Stanford University physicists, using new microwave techniques, have measured the speed of light with a precision believed to be 10 to 20 times that of previous methods. The accomplishment, of vital interest to many branches of science and offering military applications in the use of radar and loran, was announced recently.

The announcement, climaxing five years of research, set the new figure for the speed of light at 186,280 miles per second compared to the generally accepted figure of 186,272 miles per second, drawn from averages computed by many scientists over a period of 25 years. Most of the earlier computations were made by direct methods measuring visible or near visible light waves, generally over a long distance. The Stanford figure was arrived at by measuring the characteristics of radio waves, which have the same speed as light waves, in an enclosed cylinder $4^1/_2$ inches high and $9^8/_{10}$ inches in diameter.

The technique, while requiring complicated controls for precision measurements, is so relatively simple that first-year graduate students in a regular 3-hour laboratory period measure the speed of light with accuracy comparable to the best results secured by A. A. Michelson in the experiments which won the late American physicist the 1907 Nobel prize in physics. To get greater accuracy, however, requires rigidly precise controls, infinite pains, measurements accurate to a millionth of an inch, and tedious calculations which occupy an expert mathematician for a month or more. The scientists believe that their present calculation of the speed of light is accurate to within 0.0002 per cent.

Dr. Edward Ginzton examines the cylinder, machined to accuracies of a millionth of an inch, used in Stanford University experiments to measure the speed of light. The small rods he is inserting in the cylinder wall support the cylinder cover. The cavity is enclosed in the larger cylinder, seen in the background, when in operation

Previously the most generally accepted value of the speed of light, 186,272 miles per second, was suggested by Dr. Raymond F. Birge of the University of California from a theoretical study and corrections of measurements made by other scientists from 1874 to 1940. This value was believed accurate to within 0.0012 per cent. Stanford physicists are currently running a new series of experiments, the results of which will not be available for five or six months. They expect these results to be even more precise than their current figure.

The idea of determining the speed of light by measuring the characteristics of radio waves in an enclosed space was originated by Dr. William W. Hansen, Stanford physicist who died in May 1949. Dr. Edward Ginzton, professor of physics and director of Stanford University's Microwave Laboratory, assisted Dr. Hansen in the development of experimental techniques for the speed of light research and has supervised the research since Dr. Hansen's death. The major part of the research, which was financed by the Sperry Gyroscope Company, was done by Dr. Kees Bol and Dr. William J. Barclay, both graduate students in physics at Stanford.

The manner in which the speed of light measurement was made is simple as compared with other scientific techniques, and all the equipment could fit on a table 10 or 15 feet long. It is a matter of determining the resonant pitch or frequency of the cylindrical cavity and its precise dimensions. Resonant frequency is similar to the sound created by a vibrating tuning fork held over a tube of such a length that its own natural pitch is the same as that of the tuning fork. The sound is much larger for the tube's particular natural frequencies than it is for others. Similarly the frequencies at which the electrical vibrations in the cylinder are strongest are the resonant frequencies of the cavity.

The speed of light is determined by a simple formula:

$$\text{Wave Length} \times \text{Resonant Frequency} = \text{Speed of Light.}$$

While the theory is relatively simple, the execution is highly complex. The temperature at which the experiment is carried out, for example, cannot vary more than a 0.01 degree centigrade. The measurements of the cavity alone, accurate to a millionth of an inch, took several months with two men working full time. Miniature contour maps had to be made of the covers of the cavity so that the effect of any deviations could be calculated mathematically. Spacer rods, which held the cover in place, had to be measured so accurately that the scientists knew within a 0.0001 inch how much they were compressed by the weight of the disk cover, and the rods themselves had to be equal in size to within a few millionths of an inch.

These are just samples of the problems, which also extended into such fields as measuring the conductivity of the silver-plated walls of the steel cavity and knowing how much radio waves penetrated into the metal, and how to introduce the power into the cavity and how to get it out and still know how much these operations influenced the results. Theories had to be developed on all these possible variables and the theories then tested experimentally. The research, although simple in concept, took five years and the full-time efforts of two men over the entire period.

To scientists, the speed of light is one of the most fundamental constants of nature and as such is worth knowing with the greatest possible accuracy. The new figure is of value to physicists, astronomers, and engineers, since many basic formulae in all three fields have the speed of light as a factor. It is also of importance in such fields as radar and loran, where calculations of the speed of radio waves, which are the same as that of light, determine the distance of targets such as ships or points of land.

Curiously enough, American and English authorities have reported difficulty in using loran to determine ship positions with precision in the Atlantic. A check of this trouble indicated that the ships were always

Future Meetings of Other Societies

American Management Association. General Management. January 15–18, 1951, Biltmore Hotel, Los Angeles, Calif.

American Society for Testing Materials. Spring Meeting. March 5–9, 1951, Cincinnati, Ohio.

American Society of Tool Engineers. Annual Meeting. March 15–17, 1951, Hotel New Yorker, New York, N. Y.

Conference on Industrial Personnel. March 19–23, 1951, Columbia University, New York, N. Y.

Fourth Annual Conference for Protective Relay Engineers. March 26–28, 1951, Agricultural and Mechanical College of Texas, College Station, Tex.

Institute of the Aeronautical Sciences. 19th Annual Meeting. January 29–31 and February 1, 1951, Hotel Astor, New York, N. Y.

National Association of Corrosion Engineers. March 13–16, 1951, Hotel Statler, New York, N. Y.

Pennsylvania Electric Association. Winter Meeting of Transmission and Distribution Committee. February 1–2, 1951, William Penn Hotel, Pittsburgh, Pa.

Society of Plastics Engineers, Inc. Seventh Annual National Technical Conference. January 18–20, 1951, Hotel Statler, New York, N. Y.

Society of the Plastics Industry. Sixth Annual Technical Session. February 28 and March 1–2, 1951, Edgewater Beach Hotel, Chicago, Ill.

t of the expected position by an identical argin of error. To overcome this irregu-ity, the loran experts adopted an arbitrary ure for the speed of light—a figure which aced the ships in the proper position—d a figure which is almost precisely the lue obtained in the Stanford research.

Scientists, skeptical of anything which s not been proved beyond doubt, con-lered this merely an interesting coincidence ace there were other factors, possibly mospheric conditions, which might be volved in the irregularity of the loran easurements.

British physicists, using a technique nilar to Stanford's, have duplicated the anford experiment and arrived at a figure ry close to the current measurement, though not so accurate since the British perimental controls were not so rigid. A vedish scientist, working with conventional otical methods, also has arrived recently a result similar to the Stanford one.

In their current experiments, the Stanford ientists are having some of their equipment librated by the National Bureau of andards, Washington, D. C.

The precision of the frequency measure-ent, which is just as important as the curacy of the physical measurements of e enclosed cavity, has been obtained by nerating a 10-centimeter wave with the tanford-developed Klystron and then check-g this frequency against the standard equency broadcast by Station WWV of e Bureau of Standards.

Iedical Diagnosis Possible Over TV with New X-Ray Machine

The first television medical conference nd diagnosis in history appeared on "The ohns Hopkins Science Review" over the uMont Network December 5th, 1950. -ray images of a patient's chest were shown consulting doctors in Baltimore, New ork, and Chicago, and the injury was iagnosed and treatment prescribed over the levision hookup.

Metal parts from an industrial accident ere clearly visible in the patient's body nd it was reported that there was blood in e sputum. No movement of the metal arts was observed when the patient took eep breaths, and he reported no pain. hen the doctor placed his hand on the atient's back with slight forward and ackward motion; the patient felt pain nd the particles were observed to move. aving seen this over television (TV), the octors in New York and Chicago held a onsultation with the doctor in Baltimore. he patient was advised that by rather mple surgery the particles could be removed nd his pain relieved.

The showing was made possible by the evelopment of a new X-ray machine ngineered along TV patterns. This revolu-onary machine is an extremely sensitive V system by which the X-ray images, enerally of low brightness, are amplified om 300 to 3,000 times. By means of an ectronic pickup the brightened images are ansmitted over the television network and e increased brightness makes it possible see the beating of the heart and the ex-ansion and contraction of the chest due to reathing.

Heretofore, two methods of X-ray diag-nosis have been available. The first was the conventional, lengthy, and expensive process of making an X-ray negative, then studying it on an illuminated view box. The second method was to place the patient behind a fluoroscope and look directly into the interior of the body. However, with the conventional fluoroscope, images are too dim for an electronic pickup. The doctors first have to sit in a dark room for a period of time to accommodate their eyes to the low level of illumination before they are able to see images with any degree of accuracy.

The new X-ray machine not only saves time but enables the operator to use a lower X-ray output, thereby decreasing the danger of excessive X-ray absorption by the patient and the operator. Dr. Russell H. Morgan, Chief of Radiology for The Johns Hopkins Hospital, developed the new X-ray machine with the assistance of the United States Public Health Service and the Radio Cor-poration of America Laboratories at Prince-ton, N. J., and Lancaster, Pa. The program was presented by the studios of WAAM in Baltimore and the demonstration also served as a hearing before the Federal Communica-tions Commission on increased uses of TV.

New Standards of Design Featured at 19th Power Show

Advanced standards of design applied in modern power plants were featured by the more than 300 exhibitors at the 19th National Exposition of Power and Mechanical Engi-neering at Grand Central Palace in New York. The Exposition was held under the auspices of the American Society of Me-chanical Engineers (ASME), coincident with the annual meeting of the Society.

Of greatest interest to business executives, industrialists, and engineers who made up the principal audience was the equipment which directly reflected the forward trend in generating plants, much of which is specified for units now under construction or presently planned by power-consuming industries and public utilities. Equally important is the application of much of the equipment which was on display to existing plants. In many instances, modifications now possible for the first time will raise efficiencies to levels that were literally out of sight only a few years ago.

In great part, new equipment for power production and mechanical processing re-flects the thinking in engineering circles over the past few years which spells out the objec-tive of getting more heat out of the fuel and more work out of the heat. This requires that the difference between the lowest and the highest temperatures in power plant or heat process be increased. The result is that today combustion is being effected and steam is being generated commercially at tempera-tures that formerly were impossible of attain-ment for lack of materials that would with-stand high heat and extreme pressures.

Advanced standards of design were re-flected in improved methods and equipment for treating fuel before it enters the com-bustion chamber, providing a wider latitude in the selection of fuel, a hotter fire, and im-proved extraction of the heat. Exhibits showing advances in this field included grates, fire-boxes of new design, and refractories of improved durability.

Numerous displays were developed espe-cially for educational purposes. At one booth a typical pressure-loss testing hookup, counterpart of laboratory equipment used in valve design, was shown. This equipment demonstrated comparative flow character-istics using half-section models of conven-

Some of the displays which were featured at the 19th National Exposition of Power and Mechanical Engineering held at Grand Central Palace, New York, N. Y.

tional and streamlined valve bodies, emphasizing the superior opening action and lower pressure-drop of newly developed piston type check and stop-check designs.

Also educational in purpose was the display of one of the great oil companies, featuring a model hydrostatic bearing and also a lucite model sleeve bearing to demonstrate pressures developed by the rotation of the journal. Another visual demonstation at the same booth was a plastic model turbine of a lubricating system revealing some important developments in this problem.

The scope of the Exposition included a wide range of auxiliary equipment suitable for all manner of industrial plants as well as generating stations. These were steam and Diesel engines, packaged boilers showing remarkable efficiencies considering their relatively small size, power transmissions, conveyor systems, and material handling equipment in considerable variety.

The array of electrical apparatus was comprehensive and included on the power side, exclusive of signal systems and controls, an assortment of direct drives, variable speed drives applicable to mechanical equipment of many kinds, as well as variable speed transmissions applicable to synchronous motors.

Several innovations in mechanical design were shown, serving different purposes and applicable in a variety of ways. One of the most remarkable of these was a magnetic clutch which is electrically controlled and shows no wear on the torque transmitting surfaces.

Dr. Irving Langmuir Receives John J. Carty Gold Medal

Dr. Irving Langmuir, retired associate director of the General Electric Research Laboratory, recently was awarded the John J. Carty Gold Medal of the National Academy of Sciences. The ceremony took place during the fall meeting of the Academy, which was held at the General Electric Research Laboratory.

The Carty Medal and Award were established in 1930 in honor of the late John J. Carty, a member of the Academy, by his close associates, as a token of esteem on the occasion of his retirement from the Vice Presidency of American Telephone and Telegraph Company. The award may not be made more often than once in two years and may be conferred on anyone who, in the judgment of the National Academy of Sciences, has made noteworthy contributions to the advancement of fundamental or applied science in any field. In addition to the Gold Medal and a bronze replica, the bestowal carries with it the award of the net accumulated income since the time of the preceding award.

Dr. Langmuir is the recipient of many awards, including the Nobel Prize in Chemistry, the Faraday Medal of the British Institution of Electrical Engineers, and the Franklin Medal of the Franklin Institute in Philadelphia, Pa. The award to Dr. Langmuir, in 1932, of the Nobel Prize was the first made to an American industrial chemist. Regarded as one of the great scientists of modern times, Dr. Langmuir is both physicist and chemist.

During his 40 years with General Electric his researches have made possible many of our modern conveniences. The efficient and economical lights which we use in our homes, factories, schools, and street lighting systems are, to a large extent, the result of his improvements on the gas-filled lamp. His high-vacuum tube permits the use of high voltage in sending and receiving radio broadcasts and is generally considered an important factor in the development of that field.

Together with Dr. Vincent J. Schaefer, he developed an extremely dense screening smoke which proved highly effective in covering the movements of our troops and supplies in World War II.

Dr. Langmuir's contributions to pure scientific knowledge are considered of equal importance to his developmental work. His studies on electron emission and on gaseous discharges are highly regarded in science. His experimentation with oil films on water uncovered an entirely new branch of chemistry, known as 2-dimensional or surface chemistry, in which phenomena are found entirely different from any known before. Experimental techniques which he developed for studying proteins and which furnished a new attack on fundamental problems of the functions of the human organism are now being used by biochemists and biophysicists in many parts of the world.

In his present capacity Dr. Langmuir is engaged primarily in activities of Project Cirrus, a joint weather research program of the United States Army Signal Corps and the Office of Naval Research in consultation with General Electric.

New Landing System for Elevators Introduced by Westinghouse

A new development by engineers of the Westinghouse Elevator Division, Jersey City, N. J., softens an elevator's landing so much that most passengers do not know when the car has stopped. In addition to making an elevator's landing so smooth, the newly developed Synchro-Glide Landing system saves a second and a half on each floor-to-floor trip. This time saving increases the passenger-handling capacity of a car up to ten per cent.

Trips are faster because Synchro-Glide permits cars to delay slowing down for a stop until they arrive much closer to the floor than do other automatic landing systems. Now a car can arrive at a point 20 inches from the floor while traveling at 250 feet per minute—an approach speed much faster than ever before possible. As a car reaches this point, the landing system is set into operation automatically.

A series of magnets, called inductors, mounted vertically on top of each elevator car, are energized. Each of these inductors, in turn, as it comes closer to the floor signals an accurate speed control to smoothly reduce the car's motor speed until it stops. Speed is reduced according to a predetermined pattern, so the slowdown is gradual and smooth.

Because the speed of the elevator is so closely regulated even during the final 20-inch landing pattern, a car equipped with the new system makes perfect pin-point landings every time. The car never overruns the floor, thus saving the time other systems need for releveling. Door openin is completely synchronized with the car' slowdown, thereby enabling passengers t enter and leave the cars more quickly, an helping to reduce over-all trip times. Th system also saves power and reduces wea and tear on the elevator equipment.

Versatile Adhesive Handles Wide Variety of Bonding Operations

"Resiment," introduced four years ag by Paisley Products, Inc., as a paper t metal labeling adhesive, has now become a extremely useful adhesive for a wide variet of bonding operations. It is reported t be suitable for many combining and laminat ing operations on similar and dissimila materials, such as cork to metal, felt t cardboard, paper to glass, fabrics to meta and it also holds to many plastics. In addi tion to its original use for fastening instructio labels, circuit diagrams, and so forth, t electrolytic tin plate, terne plate, and othe metal surfaces, it also holds effectively t varnished, painted, and enameled surfaces Resiment's value in labeling electrical trans formers, radio chassis, refrigerators an other household appliances is well estab lished, and a new use has recently been foun in applying paper labels over the varnishe and gloss printed areas of folding cartons an other paper packages.

In the combining of paper, paperboard corrugated pads, and insulation batts t plain or painted metal, aging tests of tes panels showed that Resiment maintaine good adherence to the specified surface when aged at 225 degrees Fahrenheit fo seven days, and when exposed for 100 hour at 100-per cent relative humidity at 10 degrees Fahrenheit. After air drying, i produces no objectionable odor when th panel is sealed in an airtight container a 100 degrees Fahrenheit for 24 hours. Fur thermore, no harmful effects, such as per manent staining, etching, or softening, ar reported on specified surfaces, and no dis coloration of the paper fibres is noticed.

This semifluid, white latex-resin emulsio adhesive weighs 8.4 pounds per gallon, i dilutable with water, and can be applied b hand brushing, gumming machines, or spra guns to adhere porous materials to man different, difficult nonporous surfaces. Resi ment is claimed to be fast setting, holdin porous materials and labels immediately o contact with a permanent bond that wi not shrink, crystallize, or allow assembli to delaminate. In table-model gummin machines it operates without foaming o build-up on the rollers.

ASA Approves New American Standard for Receptacles

A new American Standard for Groundin Type Attachment Plug Caps and Receptacl has just been approved by the America Standards Association. This standard cove the essential elements for interchangeabilit of caps and receptacles for grounding th noncurrent-carrying metal parts of portab household appliances and devices. Th standard was prepared to meet the provisio in the National Electrical Code that requir

at least one receptacle outlet of the 3-pole type for the connection of laundry appliances in every dwelling occupancy. In places other than residential occupancies, the Code requires that exposed metal parts of portable appliances used in damp or wet locations or by persons standing on the ground or on a metal floor shall be grounded.

This new standard assures interchangeability of the plugs and receptacles designed for grounding purposes. In addition, it provides that they must meet the safety requirements of the Underwriters' Laboratories 1948 Standard for Attachment Plugs and Receptacles. The standard calls for a receptacle which will not only receive a cap having three blades (a U-shaped or round grounding blade and two standard, parallel, polarized blades) but also shall permit the insertion of any standard 125-volt polarized or non-polarized parallel 2-blade cap. The contacts must be arranged so as to prevent reversal of polarity if the grounding cap is moved from one side of the duplex receptacle to the other. The exact location of the slots in the receptacles is specified. The type of metal to be used for grounding contacts and the position of the grounding conductor terminal are specified also, along with the provision that it shall not be possible to insert the grounding blade in either of the rectangular slots of the receptacle. Dimensions and arrangement of the cap and receptacle are outlined in drawings.

The use of the new type of grounding cap, or plug, and receptacle described in this standard presupposes the use of a 3-conductor cord. The standard provides that one of these three conductors be attached to the frame of the appliances. This is the "grounding conductor." It must have a green outer covering to identify it, according to the requirements of the National Electric Code.

A committee sponsored by the National Electrical Manufacturers Association developed this standard under the procedures of the American Standards Association.

RCA and I.T. &T. Sign Agreements Covering Radio and TV Inventions

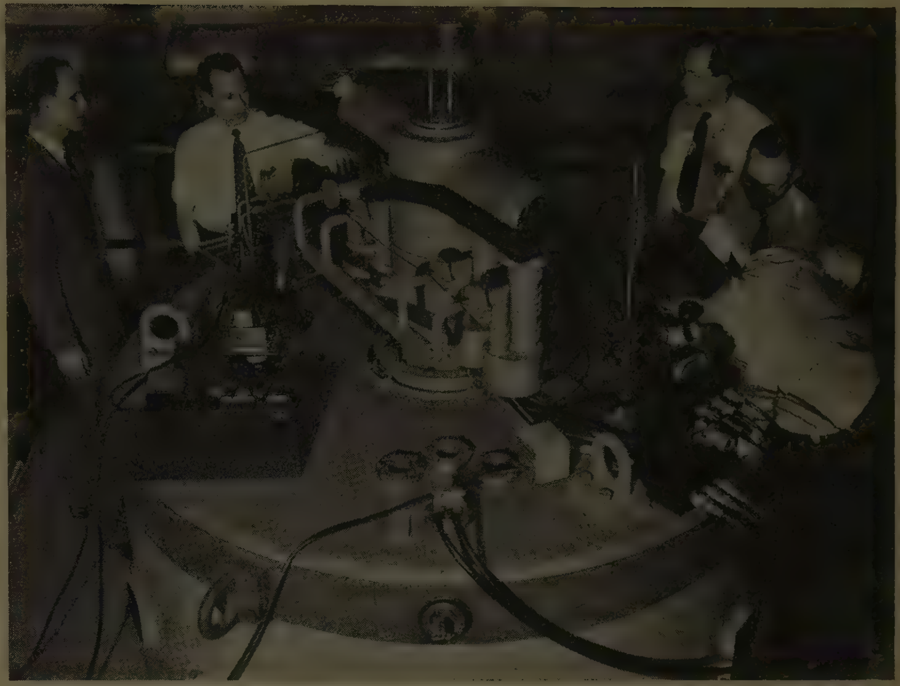
Agreements between the Radio Corporation of America (RCA) and the International Telephone & Telegraph Corporation (I.T.& T.) providing for the exchange of licenses under radio, television, and electronic inventions by these companies and their manufacturing subsidiaries were announced recently.

The agreements, effective immediately and extending to December 1954, cover such commercial apparatus as broadcasting transmitters, television transmitters, and radar equipment, as well as cathode-ray and power tubes developed by the two companies and their subsidiaries. Similar agreements are effective between the Canadian subsidiaries of RCA and I.T.&T.

Under the terms of the agreements, standard licenses are granted by RCA to Federal Telephone and Radio Corporation and Federal Telecommunication Laboratories, Inc., manufacturing and research associates of I.T.&T., to manufacture and sell commercial apparatus and power tubes utilizing RCA developments. Licenses are granted to these two companies and to Capehart-Farnsworth Corporation, another domestic associate of I.T.&T., for cathode-ray picture tubes developed by RCA.

I.T.&T. and its associates also have access to RCA's color television inventions under the agreements. Similarly, RCA is licensed to use inventions of I.T.&T.'s associated companies in the manufacture of power tubes and commercial radio apparatus.

New Synchrotron to Be Used in Atomic Research



The illustration shows scientists at work on the 300,000,000-volt synchrotron now under construction in the General Electric Research Laboratory. This machine, to be used in atomic research, eliminates the huge iron core formerly used in such equipment and so makes the device much more compact than others giving radiation of comparable energy. Left to right are Dr. J. L. Lawson, Dr. H. L. Kratz, Dr. W. B. Jones, Dr. H. B. Voorhies, and Dr. G. L. Hagan

New Development Enables Jet Planes to Fly Higher, Farther

Dr. Howard M. Elsey, consulting chemist at the Westinghouse Research Laboratories, Pittsburgh, Pa., revealed that specially treated carbon brushes which pick up and relay power to the plane's electric system have increased the high-altitude life of jet engines by many times. Development of the new brush was a key factor in the United States Air Force's program to extend the range and flying hours of jet planes without frequent brush replacement. In the extremely dry air of 40,000- or 50,000-foot altitude, these brushes must create their own lubrication; otherwise they will grind themselves to powder against the copper commutator and the flow of electricity will stop.

Dr. Elsey solved the problem by impregnating the brushes with a special chemical compound belonging to the same family as table salt. As the brushes are pressed against the revolving commutator, the new ingredient promotes the formation of a lubricating film that prevents harmful friction at the highest altitudes attainable. Despite its tenacity, the lubricating film is so thin that 2,000 layers of it would barely equal the thickness of a sheet of paper.

The temperatures created on the face of the brushes during the starting phase of jet engines using starter-generators may run as high as 1,000 degrees Fahrenheit. This may evaporate the chemical treatment in the carbon brush, so that when the plane reaches an altitude of 40,000 or 50,000 feet, the brush cannot produce the necessary lubricating film. The new chemical treatment can stand up under both the terrific heat of jet engine starting and the thin, dry subzero air of stratosphere flying.

World's Largest Telephone Set Manufacturing Plant Opens

The world's largest telephone set manufacturing plant, capable of producing more telephone sets annually than all the telephones presently in operation in France or Canada, was placed in operation recently at Indianapolis, Ind., by the Western Electric Company, Inc., manufacturing and supply unit of the Bell Telephone System. Located on a 133-acre tract six miles northeast of

the center of Indianapolis, the new plant, constructed under the supervision of Western Electric engineers, covers nearly 20 acres and will employ approximately 6,000 men and women.

A plant of this size and design was necessary to meet the volume requirements and the exacting demands for the precision manufacture of modern telephone instruments for the nation's expanding telephone network. There are now 34,750,000 Bell System telephones in operation, which is nearly 2,000,000 more than a year ago. This plant will be the Bell System's only source of telephone sets. Over 18 different types of telephone sets will be manufactured in the plant including the new 500 type telephone set recently designed by Bell Telephone Laboratories now being field tested.

The main manufacturing building will house several thousand machines beneath the more than $2^1/_2$ miles of overhead conveyors carrying apparatus and parts to and from assembly operations. Manufacturing areas are laid out so that piece parts manufactured for each subassembly are directly behind the subassembly areas with these lines systematically arranged so that they flow into the final assembly areas. About 10,000 2-tube fluorescent fixtures suspended on messenger cables and trolley ducts provide a flexible illumination system where fixtures may be relocated or added to provide additional illumination when needed. Dust control, essential in the manufacture of precision telephone sets, is accomplished by introducing filtered fresh air into the building and maintaining the inside atmospheric pressure slightly higher than the outside.

The entire plant will consume an amount of electric power equivalent to that used by a community of 35,000 persons. This is delivered to two substations by the Indiana Power and Light Company at 33,000 volts from a loop which surrounds the city. To distribute the power in the plant 38 miles of electrical conduit are used.

NSPE Considers the Problems of Manpower Mobilization

A 4-point statement suggesting action to be taken by the government during the present emergency on mobilizing engineering manpower was adopted by the National Society of Professional Engineers' (NSPE) Board of Directors at a recent meeting in Little Rock, Ark.

The four proposals are:

1. That a realistic deferment policy be initiated in order to guarantee the future supply of technical personnel throughout an extended mobilization period.
2. That during a period of extended emergency a review board of eminent engineers and scientists be appointed to maintain a balance between requirements for engineers to meet the military needs and defense production needs.
3. That steps be taken within the Armed Forces to insure the proper utilization of professional personnel during time of war.
4. That if full mobilization is necessary steps be taken to assign technical personnel in civilian services where their greatest contribution to the defense effort can be made.

Elaborating upon the student deferment problem, the NSPE proposed a plan whereby there would be a manpower mobilization board for engineering and science student deferments which would make specific determinations for requirements for future national needs in engineering and science.

New Corrosion Testing Facilities Added to Kure Beach Project

Formal opening of the new Harbor Island addition to the Kure Beach project took place recently. Approximately 100 industrial and government officials attended the opening, headed by Admiral C. D. Wheelock, deputy chief of the United States Navy's Bureau of Ships, who emphasized the value of the corrosion studies being carried out at the project to the Navy as a whole and to the Bureau of Ships in particular.

The sea water corrosion testing station at Kure Beach, N. C., was established by The International Nickel Company in 1935 for the immediate purpose of comparing the corrosion resistance of low alloy steels with carbon steel. Soon other materials were added to the program so that eventually comparative tests were being made on all kinds of ferrous and nonferrous metals and alloys. The testing facilities have since been further extended to observe the behavior of several kinds of protective coatings—both metallic and organic—including anti-fouling formulations, the effects of marine growth on wood as well as on metals, and even the results of exposure to sea spray and sea air upon rope.

The new laboratory at Harbor Island offers improved means for preparing specimens for test and examining them afterwards. Another necessary feature is the maintenance of test records and performance of materials.

GE Converts Utica Plant for Civil Defense Equipment

General Electric Company will reopen a former radio tube plant in Utica, N. Y., and convert it for the manufacture of emergency radio communications equipment. Dr. W. R. G. Baker, General Electric Vice-President, said the company is also planning a broad program which would make its electronics experts and their knowledge available for civil defense planning in communities throughout the country. In areas under heavy enemy attack, when normal telephone and radio facilities are destroyed or seriously disrupted, emergency radio communication equipment will be ready to operate.

The new General Electric Utica plant is expected to be in full operation by June, employing about 425 people, and manufacture of the communications equipment will be moved gradually from the company's Electronics Park plant at Syracuse.

Oak Ridge to Give 2-Week Medical Course in Radioisotopes

A special 2-week advanced medical course in radioisotope work will be given by the Oak Ridge Institute of Nuclear Studies beginning on February 5, 1951. The course, dealing with radioisotopes in therapy and in clinical studies, is intended for research workers in the field of medicine who have had some experience in the basic techniques of using radioisotopes. Lecturers from hospitals using radioisotopes, Oak Ridge Laboratory, and staff members of the Medical and Special Training Divisions of the Institute will participate in the course.

A limited number of applicants who are able to attend for one week only can be accommodated. A fee of $25 will be charged for the course. Applications are available from Dr. Ralph T. Overman, Chairman of the Special Training Division, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tenn.

New Proof and Reprint Service Adopted by London Engineers

The following procedure has been adopted by the Proof and Reprint Service of The Institution of Electrical Engineers, London, England. Formerly the proofs of a paper allocated for reading before The Institution of Electrical Engineers were made available to members only ten days before the meeting; thus, if accepted at a time when the current program of meetings was complete, authors' manuscripts might lie dormant for months.

As soon as the early proofs of a paper are available, an announcement to that effect, together with a synopsis, appears in the monthly *Journal* of The Institution. Application for such proofs can then be made, and those who avail themselves of this service are given the opportunity of applying for a reprint, from the *Proceedings* of The Institution, of the paper in its final form, together with a report of the discussion. The object of the reprint service is to ensure that the permanent record available to its users shall not consist of an early proof which may contain errors and will certainly not include discussion.

The inclusive charge for an early proof and its associated reprint is 2s.6d., approximately $0.35, (post free). This charge is made whether or not the reprint is required, but a reprint alone can be supplied at the price of 1s.6d., approximately $0.21, (post free) if ordered shortly after the paper has been read in London. Requests for proofs should be sent, accompanied by a remittance, to The Secretary, The Institution of Electrical Engineers, Savoy Place, London, W.C. 2, England.

Organization of Company Standardization. To assist manufacturing concerns in the organization of their standardization work, a private 5-day seminar, especially designed for company representatives, will be held by Dr. John Gaillard, mechanical engineer American Standards Association, and lecturer at Columbia University. The dates are January 22–26, 1951, and the place is Room 501-A, Engineering Societies' Building, 33 West 39 Street, New York, N. Y. The seminar will consist of ten conferences each comprising a lecture by Dr. Gaillard followed by round-table discussion of problems of interest to the conferees. For details and registration write to Dr. Gaillard at 400 West 118 Street, New York 27, N. Y. or telephone him at Murray Hill 3-3058.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Waves of All Velocities

To the Editor:

In an Electrical Essay[1] by Dr. J. Slepian entitled "Waves of All Velocities," he concludes that "electromagnetic waves in free space exist which travel with any and all velocities."

It appears that Dr. Slepian may have employed the so-called wave equation without due consideration of its origin. The proper approach in the analysis of electromagnetic waves is aptly illustrated in a statement by Professor Silver, Associate Professor of Electrical Engineering at the University of California, when he says: "Though all fields that satisfy Maxwell's equations necessarily satisfy the wave equations, the converse is not true. A set of field vectors **E** and **H** which satisfy the wave equations constitute an admissable electromagnetic field only if at the same time they satisfy Maxwell's equations. Furthermore, the fields must behave properly at the boundaries concerned. If the region is infinite in extent, separate attention must be paid to the behavior at infinity."[2] The so-called wave equation can be derived from Maxwell's equations.

It generally is concluded, and it is in fact true, that the velocity of propagation of electromagnetic waves in free space is a constant independent of the frequency of the radiation. This velocity is given by $v=\dfrac{1}{\sqrt{\mu_0\epsilon_0}}=c$.

Dr. Slepian's argument is best disqualified by assuming his conclusion and showing the inconsistency in his hypothesis. The proposed wave has field components H_y and E_z, and is propagated along the x-axis perpendicular to any $y-z$ plane containing the electric and magnetic field vectors **E** and **H**. . . Thus, assuming Dr. Slepian's conclusion, we are led to contradiction in the hypothesis.

It is even more interesting to determine whether or not there can exist a plane wave of the form

$$u=A\sin\frac{2\pi}{\lambda}(x-vt)\cos\frac{2\pi}{\lambda}\left(\sqrt{\frac{v^2}{c^2}-1}\,y\right),\quad v>c$$

where the amplitude is an arbitrary function of position over an equiphase plane. Plane waves characterized by unidirectional propagation travel at right angles to equiphase surfaces. The equiphase surfaces are families of planes having the same field intensity and are at right angles to the direction of propagation.

The fact is apparent that merely satisfying the wave equation is not a sufficient condition to establish $u=f(x, y, z, t)$ as an electromagnetic wave. It also is apparent that improper application of electromagnetic theory often leads to erroneous conclusions concerning the velocity of propagation of electromagnetic waves. How about this?

REFERENCES

1. Waves of All Velocities, J. Slepian. *Electrical Engineering*, volume 68, 1949, pages 1080–81.

2. Microwave Antenna Theory (book), Samuel Silver. McGraw-Hill Book Company, Inc., New York, N. Y., page 73.

EDWIN L. PETERSON (Student Member)

(Tulane University, New Orleans, La.)

To the Editor:

Mr. Edwin L. Peterson, in the preceding letter, suggests that while waves of all velocities may be found which are solutions of the wave equation

$$\frac{1}{c^2}\frac{\partial^2 u}{\partial t^2}=\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2} \qquad (1)$$

no waves of all velocities may be found which are electromagnetic fields and which also satisfy Maxwell's equations.

However, the function which I gave in my essay (*EE, Dec '49, p 1080–81*)

$$u=A\sin\frac{2\pi}{\lambda}(x-vt)\cos\left(\frac{2\pi}{\lambda}\sqrt{\frac{v^2}{c^2}-1}\,y\right) \qquad (2)$$

and which satisfies the wave equation 1, may be taken as the z-component of a vector potential, with the other components, and the scalar potential zero, thus yielding the electromagnetic field

$$E_x=0 \qquad H_x=-A\frac{2\pi}{\lambda}\sqrt{\frac{v^2}{c^2}-1}\times \sin\frac{2\pi}{\lambda}(x-vt)\sin\left(\frac{2\pi}{\lambda}\sqrt{\frac{v^2}{c^2}-1}\,y\right)$$

$$E_y=0 \qquad H_y=-A\frac{2\pi}{\lambda}\cos\frac{2\pi}{\lambda}(x-vt)\times \cos\left(\frac{2\pi}{\lambda}\sqrt{\frac{v^2}{c^2}-1}\,y\right)$$

$$E_z=-A\frac{2\pi v}{\lambda}\sin\left(\frac{2\pi}{\lambda}[x-vt]\right)\times \cos\left(\frac{2\pi}{\lambda}\sqrt{\frac{v^2}{c^2}-1}\,y\right) \qquad H_z=0 \qquad (3)$$

This field does satisfy Maxwell's equations and remains finite at infinity, just as does the more orthodox plane wave which Mr. Peterson considers. It then meets the quoted criterion of Professor Silver, and therefore "constitutes an admissible electromagnetic field." However, the mathematical form of equations 3 gives the wave a velocity $v \neq c$, if the definition suggested in my essay for the velocity of a wave is used.

In his attempt to show the impossibility of the wave, equations 3, Mr. Peterson erred by assuming that H_x had to be zero, or that the field vectors are necessarily perpendicular to the direction in which the wave is said to be moving. Equations 3 show that this is not the case.

The resolution of the paradox of my essay, if there may be said to be one, lies in examining what meaning may be attached to the notion of the velocity of an arbitrary wave. If the definition is based on equations 3, then electromagnetic waves of all velocities do exist. They are regularly observed in wave guides.

However, the question may be asked whether all waves may be reduced to the form

$$u=f(x-vt, y, z) \qquad (4)$$

The answer is no, and for such waves as cannot be reduced to equation 4, the velocity is as yet undefined.

The question may be further asked whether for all waves as can be reduced to equation 4 the reduction is unique? The answer is again no. Thus the ordinary plane wave

$$u=f(x-vt) \qquad (5)$$

by a rotation of axes about the z axis though an angle becomes

$$u=f(x'\cos\alpha-y'\sin\alpha-ct) \qquad (6)$$

which can be written as

$$u=f\left(\left[x'-\frac{c}{\cos\alpha}t\right]\cos\alpha-y'\sin\alpha\right) \qquad (7)$$

giving a velocity in the x' direction equal to $v=\dfrac{c}{\cos\alpha}$ or it can be written as

$$u=f\left(\left[y'+\frac{c}{\sin\alpha}t\right][-\sin\alpha]+x'\cos\alpha\right) \qquad (8)$$

giving a velocity in the y' direction equal to $v=-\dfrac{c}{\sin\alpha}$.

J. SLEPIAN (F '27)

(Westinghouse Research Laboratories, East Pittsburgh, Pa.)

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

MECHANICS. By J. E. Boyd and P. W. Ott. Third edition. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1950. 422 pages, diagrams, charts, tables, 9¼ by 6 inches, cloth, $4.50. Emphasizing fundamental principles, this textbook focuses attention on the physical meaning of the operations involved in the solution of problems. In this third edition, additional material on machines and friction, graphical methods, forces in space, and kinetics is included. There is an expansion of the treatment of virtual work, including an elementary discussion of the stability of systems of one degree of freedom. In addition, new solved and unsolved problems are added.

PLASTICITY OF CRYSTALS. By E. Schmid and W. Boas. F. A. Hughes and Company, Ltd., Bath House, Piccadilly, London, W. 1, England, 1950. 353

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, fabrikoid, 35s. Of interest to those concerned with the mechanism of the deformation of metals, this translation of an original German treatise provides a comprehensive treatment of the subject. Following a review of fundamentals and a description of the mechanisms of deformation, there is a fully detailed account of the application of these principles to metal crystals. Then the behavior of ionic crystals and a number of hypotheses are treated. An extensive bibliography is included.

INDUSTRIAL ACCIDENT PREVENTION. By H. W. Heinrich. Third edition. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1950. 470 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by $6^1/_4$ inches, cloth, $5.00. Placing special emphasis on the human factor in safety work, this book provides full coverage from fundamentals through specific methods and devices to the setting up and carrying out of full-scale safety programs. New chapters on motor-vehicle fleets, supervision, personal protective devices, and a short-form safety course are included in this edition. New material is also added to the sections on accident hazards and production faults, supervisory control of employee performance, and cause analysis of boiler and machinery accidents.

INSTALLATIONS ÉLECTRIQUES À HAUTE ET BASSE TENSION, Volume II. (Électrotechnique Appliquée.) By A. Mauduit. Second edition. Dunod, Paris, France, 1950. 1,302 pages, illustrations, diagrams, charts, tables, $9^1/_2$ by $6^1/_2$ inches, fabrikoid, 4,850 frs. This second volume of a 2-volume set provides a full treatment of both theory and practice in connection with switches, interrupters, circuit breakers, and relays of various types. The problem of line protection is discussed with detailed consideration of overcurrents and overvoltages. The practical operation of distribution systems is described, dealing with the central station, substations, and overhead lines. The final chapter is devoted to system stability, interconnection, costs and rate-setting. The two volumes together provide coverage of both low- and high-tension installations.

IONIZATION CHAMBERS AND COUNTERS. (Cambridge Monographs on Physics.) By D. H. Wilkinson. Cambridge University Press, American Branch, New York 10, N. Y., 1950. 266 pages, diagrams, charts, tables, $8^3/_4$ by $5^3/_4$ inches, cloth, $4.50. This book discusses the principles of operation, the construction and limitations of the ionization chamber, proportional counter, and Geiger counter. The factors governing the relation between the properties of the ionizing particle which passes through the detector and the resulting electrical impulse are examined in detail. All the devices are discussed from the point of view of their speed of operation and utility in coincidence arrangements, but no attempt is made to discuss the applications of the devices or their ancillary electronic equipment.

PAPERS ON RADIOGRAPHY, presented at the 52nd Annual Meeting, American Society for Testing Materials, Atlantic City, N. J., June 27, 1949. (Special Technical Publication Number 96.) American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1950. 95 pages, illustrations, diagrams, charts, tables, 9 by 6 inches, paper $1.75. Three of the six papers in this group deal with progress in the development and application of electrostatic and betatron-type X-ray generators operating at potentials above one million volts; one considers the X-ray machine as a tool for studying material and engineering parts in motion; the remaining two are devoted to techniques and other aspects of industrial radiography.

RADIO COMMUNICATION AT ULTRA HIGH FREQUENCY. By J. Thomson. John Wiley & Sons, New York, N. Y.; Methuen & Company, London, England, 1950. 203 pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $4.50. This book provides an account of modern developments in telecommunications employing radio waves of lengths ranging from a few meters to a few millimeters. Following introductory material, the circuits and tubes used at ultrahigh frequency are considered. Power amplifiers, frequency multipliers, and oscillators then are discussed, and receiver input circuits are treated. The three remaining chapters deal with modulation techniques, frequency control, and communication systems.

REFRESHER NOTES FOR PROFESSIONAL ENGINEERS LICENSE EXAMINATION. By J. D. Constance. Third edition. John D. Constance, 625 Hudson Terrace, Cliffside Park, N. J., 1950. Paged in sections; diagrams, charts, tables, 11 by $8^1/_2$ inches, photo-offset, stiff paper, $4.50. Of interest to those preparing for Professional Engineers License Examinations, this volume contains condensed basic information problems and their solutions from the fields of hydraulics, thermodynamics and machine design. In this third edition, 30 pages of problems are added, and a new chart on 4-bar linkages.

ERSPONSE OF PHYSICAL SYSTEMS. By J. D. Trimmer. John Wiley & Sons, New York, N. Y.; Chapman & Hall, Ltd., London, England, 1950. 268 pages, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $5.00. This book on instrumentation and the measurement process demonstrates the application of mathematical techniques to physical systems. Closely linked with cybernetics, it includes not only such physical systems as instruments, regulators, and servos, but also some reference to biological and sociological entities as well. The intent is to provide a broad general study of system response to input forces, covering feedback and other control methods. A full working knowledge of calculus is essential, and a concurrent study of differential equations is recommended.

SURVEY OF MODERN ELECTRONICS. By P. G. Andres. John Wiley & Sons, New York, N. Y.; Chapman & Hall, Ltd., London, England, 1950. 522 pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^3/_4$ inches, cloth, $5.75. Providing a descriptive rather than mathematical treatment, this book explains the fundamentals of electronics and provides a summary of applications. It is intended as a text for a short course in electronics for nonelectrical engineering students. The basic principles of construction, operation, and application of electron tubes are stressed. A knowledge of elementary physics, d-c fundamentals, and some a-c fundamentals is assumed. General references are included in the appendix.

SYMPOSIUM ON APPLICATION OF STATISTICS, presented at the First Pacific Area National Meeting, American Society for Testing Materials, San Francisco, Calif., October 11, 1949. (Special Technical Publication Number 103.) American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. 36 pages, charts, tables, 9 by 6 inches, paper, $1.00 (to members, $.75). This pamphlet contains the three technical papers, with discussion, presented at a symposium sponsored by the Committee on Quality Control of Materials. The papers deal with the economic relationship between design and acceptance specifications, the precision and accuracy of test methods, and the use of statistics to determine precision test methods.

THEORY AND PRACTICE OF INDUSTRIAL RESEARCH. By D. B. Hertz. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1950. 385 pages, diagrams, charts, tables, $9^1/_4$ by $6^1/_4$ inches, linen, $5.50. This book deals with the process of research as it applies to industry and covers the fundamental requirements of research operations. It isolates the elements of the research process analytically and then synthetically constructs an industrial research methodology. The first four chapters present theoretical background and analytical material on creative mentalities, problem solving, and scientific method. The remaining chapters apply these concepts to industrial research. A classified bibliography of books and periodical literature is included.

TRANSMISSION LINES AND FILTER NETWORKS. By J. J. Karakash. Macmillan Company, New York, N. Y., 1950. 413 pages, illustrations, diagrams, charts, tables, $9^1/_2$ by $6^1/_4$ inches, cloth, $6.00. In this exposition of elementary theory, consideration is given to pertinent conditions encountered in circuits dealing with frequencies extending from the voice range to the microwave range. The three main sections deal respectively with conventional steady-state transmission-line theory with emphasis on high-frequency applications, an introductory approach to network theory, and electric wave filters of various types. The application of Maxwell's electromagnetic field equations to wave guide transmission is discussed in an appendix.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Annual Report of the National Bureau of Standards for 1949. A summary of scientific investigations carried on during 1949, contained in a 101-page booklet. Illustrated. Available at 75 cents a copy from the Superintendent of Documents, United States Government Printing Office, Washington 25, D. C.

Sabotage—How to Guard Against. A 12-page reprint of the manual of the same title by Harry D. Farren. Available at 25 cents for single copies—quantity discounts available—from the National Foremen's Institute, Inc., New London, Conn.

Counters. A 4-page folder which explains the elements of a Geiger counter as well as the behavior of electrons, positive ions, ion clouds, and impulses. Also deals with penetrating and nonpenetrating and decaying cosmic-ray particles. Data are given on special counting circuit arrangements. Illustrated with drawings. Available from V. W. Palen, New York University College of Engineering, Bureau of Public Information, New York 53, N. Y., for 10 cents.

October 1950 Bibliography of Technical Reports. Review of the contributions of the Signal Corps to research in luminescent materials: flourescent dyes; phosphorescence; photoconductivity and related fields. Includes a chart showing materials found to be suitable for ultraviolet and infrared phosphors. Available for 50 cents per copy from the Office of Technical Services, Department of Commerce, Washington 25, D. C.

Mica and Mica Substitutes—Attendance and Transcript of Proceedings. Subjects covered by an industry-military round-table discussion between the Department of Navy and the National Security Industrial Association included: solid state synthetic mica; World War II mica research; miniature capacitors; cellulose esters; glass and vitreous enamel insulating materials; dimensionally stable ceramics; the use of block talc; integrated mica; and new uses for mica. 45 pages. Copies are available for 50 cents from the Office of Technical Services, United States Department of Commerce, Washington 25, D. C.

Radiation Instrument Catalog. Lists 543 specific items of equipments now commercially available in the United States, including Geiger counters, ionization chambers, scintillation counters, dosimeters, film badges, and so forth. Also listed are 32 instruments capable of measuring and distinguishing between the three principal types of radiation—alpha, beta, and gamma. The catalog was compiled and edited by the Atomic Energy Commission (AEC) Radiation Instruments Branch and was published by the AEC Technical Information Service. Illustrated by photographs and drawings. Available for $2.00 per copy from the Office of Technical Services, United States Department of Commerce, Washington 25, D. C.

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INDUSTRIAL NOTES ....

New Consulting Engineering Firm Formed. Microwave Associates, Inc., 303–301 Columbus Avenue, Boston 16, Mass., has been formed as a corporation to provide consulting, design, and manufacturing facilities for electronic components and equipment operating in the microwave field. Vess Chigas is production manager of the new organization.

Weston Appoints New York District Office Manager. William J. Healey has been made Manager of the Weston Electrical Instrument Corporation's New York District Office.

Sola Appoints New Sales Representatives. James Millar Associates, 1019 West Peachtree Street, N. E., Atlanta, Ga., have been appointed sales representatives for the Sola Electric Company of Chicago, Ill. Millar Associates will be exclusive representatives for the sale of Sola constant voltage transformers in the states of Mississippi, Alabama, Georgia, Tennessee, and Florida.

Allis-Chalmers Increases Land Turbine Prices. The Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has increased prices ten per cent on all land turbines and turbine generator units. The new pricing policy is in effect at time of shipment with a 10-per cent limit on upward adjustment for units rated 15,000 kw and less, and 20-per cent limit for units larger than 15,000 kw.

Financial Vice-President of B. F. Goodrich Retires. George W. Vaught, Financial Vice-President of The B. F. Goodrich Company since 1940, has announced his retirement as of December 31, 1950.

U. S. Rubber Company Appointments. Joseph A. Conlon, formerly district sales manager, Chicago branch, has been appointed manager of allied sales for the Mechanical Goods Division of the United States Rubber Company. At the same time, Edwin D. Meade, formerly manager of western railway sales, was named to succeed Mr. Conlon as the Chicago district sales manager.

Hudson Wire to Add a Midwest Plant. The Hudson Wire Company has announced its plans to establish a new magnet wire plant at Cassapolis, Mich., (in addition to its plants at Ossining, N. Y., Winsted and Norwalk, Conn., and Pownal, Vt.) in order to give faster service to its western customers.

Massa Laboratories Opens New Plant. Massa Laboratories, Inc., of Cleveland Ohio, has opened a new laboratory and manufacturing plant in Hingham, Mass., which will have every facility for the development and production of electro-acoustic apparatus.

Cold-Strip Mill to Be Installed in France. Mackintosh-Hemphill Company, Pittsburgh, Pa., has sold a Y-type, reversing cold-strip mill to S. A. Etirage et Laminage du Nord for installation in Jeumont (Nord), France. This new mill will cold roll and coil up to 16-inch widths of low-carbon, high-carbon, and alloy steels. It is the first Y-type reversing cold-strip mill to be installed in France.

New Chlorine Plant to Use De Nora Mercury-type Cells. In September 1948, the Monsanto Chemical Company announced a tentative agreement with Dr. Oronzio De Nora, head of an Italian company, to use and sell the latter company's mercury cell in the United States. Now the first sizable chlorine plant in the United States or Canada to use De Nora mercury-type cells with a rated capacity of 30,000 amperes will be erected by Marathon Paper Mills of Canada, Ltd., as the result of a contract signed recently by Marathon, the Leonard Construction Company, and Monsanto Chemical Company. The plant, which will be located at Marathon, Ontario, Canada, has been designed by Monsanto Chemical, and will be built to produce 25 tons of chlorine per day, as well as rayon-grade caustic soda, electrolytic sodium sulfide, sodium hypochloride, and synthetic hydrochloric acid.

NEW PRODUCTS ••

Air Compressors for Airplanes. The new model *RG-8100* Lear-Romec air compressor has been designed for pressurizing radar installations in high-altitude airplanes. The pump and motor rotor shaft runs on three ball bearings, prelubricated for 1,000-hour normal service life. The sliding blades (of carbon-graphite composition) and the rotor are the only moving parts, and there is positive starting and pumping at −67 degrees Fahrenheit. The compressor maintains sea level pressure from 35,000- to 50,000-foot altitude, and is rated at 80 cubic inches per minute at seven inches of mercury absolute inlet suction, against an outlet back pressure of 32 inches of mercury absolute. Equipment (with a-c or d-c motors) includes assembled pressurizing kits, consisting of an inlet type air filter-dehydrator, an absolute pressure switch, and a system check valve, mounted on a shock- and vibration-resistant panel. Further information is available from Lear, Inc., Romec Division, Elyria, Ohio.

Eight-Channel Oscilloscope. To answer the seismographic problems of a government experimental agency, The Electronic Tube Corporation, 1200 East Mermaid Lane, Philadelphia 18, Pa., has recently developed an 8-channel oscilloscope. Through the higher frequency response made possible by this instrument, users will be able to learn more about the characteristics of the earth than was formerly possible with a magnetic seismograph. Designated model *H-87*, the new oscillo

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scope consists of eight independent channels, each of which contains a single-gun cathode-ray tube, and eight a-c amplifiers with a deflection sensitivity of 10 millivolts per inch. Frequency response is 20 to 25,000 cycles per second ±20 per cent, or 20 to 150,000 cycles per second ±30 per cent. An 8-channel a-c model, with a sensitivity of 2 millivolts per inch, and a d-c model, also with a sensitivity of 2 millivolts per inch, have been constructed. The only factors common to all channels are intensifying of the cathode-ray tubes and timing marker injection. Signals are displayed on a horizontal axis for photographing on a film strip or drum with vertical travel. The power supply is independent of the indicator unit. Full details may be obtained from the company.

Multiwattage Water Heater. A water heater whose element ratings can be changed to any required voltage between 600 and 3,000 watts by shifting wiring connections has been introduced by the Westinghouse Electric Corporation's Appliance Division. Westinghouse tested the new Corox multiwattage heating element for several years before putting it on the production line. It is sickle-shaped and has four terminal screws. By changing or omitting jumpers (bus bars) the wattage can be set to comply with utility specifications to wattages of 650, 750, 1,000, 1,500, 2,000, 2,500, and 3,000 watts. Further information is available from the Westinghouse Electric Corporation, 306 Fourth Avenue, Pittsburgh 30, Pa.

Thirty-Channel Recorder. Reed Research, Inc., 1048 Potomac Street, N.W., Washington 7, D.C. has introduced a new recorder that furnishes 30 channels of information in the space required for one normal wide-chart recorder. Developed originally for use with an analogue computer, the Reed Multitron has 30 or more electrodes mounted on an insulated frame oscillating at 30 cycles per minute. Six electrodes record on each roll of teledeltos paper in 2-inch channels. Impressions are made on the paper at the instant in the half-cycle when the voltage being measured exactly equals that of the precision measuring potentiometer, which is driven by the frame. Accuracy obtained is better than ±1 per cent. Data may be recorded as often as every two seconds. The Multitron is available in multiples of six, from 12 to 96 channels. Additional information may be obtained from the company.

New Type Double Triode. A double triode receiving-type tube designed particularly for wide-angle vertical deflection in large television picture tubes, which will handle the entire vertical deflection system has been announced by the Radio Tube Division of Sylvania Electric Products, Inc. The tube, type *6BL7GT*, includes two identical triode sections, each providing high gain, high plate current, and low plate resistance. A rigid low center of gravity element structure mounted on a circular glass header similar to that used in lock-in

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types provides uniform, wide spacing of leads, uniform inter-electrode characteristics, and advantages for high-voltage operation. The *6BL7GT* also may be used for cathode follower applications. Used as a line amplifier, each triode section will provide a good 5-volt signal in 75-ohm coaxial cables. It also performs well as two medium power output triodes in cathode-type push-pull amplifiers where high fidelity output and compactness are desired. Sylvania Electric Products, Inc., Radio Tube Division, 500 Fifth Avenue, New York 18, N. Y., will supply further details.

The Dumitter. The Dumitter, developed by the Television Transmitter Division, Allen B. Du Mont Laboratories, Inc., 1000 Main Avenue, Clifton, N. J., takes the composite video or aural signal from any standard television camera chain and feeds it via a single cable to the regular antenna terminals of any standard television receiver, thus eliminating the bulky equipment previously required for the same function. No operator is needed, and up to 125 receivers can be driven simultaneously. Transmission is excellent over several thousand feet. Each receiver is tuned to either channel 2 or 3, depending on the setting of the Dumitter, and the antenna lead-in is disconnected from the receiver while the Dumitter signal is being received. Switching from the Dumitter line to antenna lead-in permits the receiver to function on either closed-circuit or standard telecasting at will. No circuit or component changes are required. This instrument can distribute color as well as monochrome signals. Additional information may be obtained from the company.

Two-Speed Magneclutch. The Vickers Electric Division of St. Louis, Mo., has announced a new reversing or 2-speed Magneclutch, with two driving members and only one driven member. The two driving members rotate continuously in opposite directions, and a simple reversing drive, which is controlled by energizing the proper excitation coil, is achieved. Because of the single, low-inertia driven member, there is no backlash in the output shaft. A 2-speed transmission (accomplished by driving the input members at different speeds in the same direction) is advantageous for remote control, since the excitation power is low and three wires can easily carry the current over long distances. The two speeds may be almost the same, or they may be widely different. Any slip losses are dissipated in the clutch, and even in cases where the clutch does not slip while running, changing the speed or direction of rotation of high inertia loads often causes large losses during the transition period. Consequently, since each Magneclutch has a definite limit to the amount of heat it can dissipate, each application must be properly evaluated so that a suitable size unit may be chosen. Complete information on these new clutches may be obtained from Vickers Electric Division, Vickers, Inc., 181[illegible] Locust Street, St. Louis 3, Mo.

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Frequency Standard and Test Set. The Freed Transformer Company, Inc., has introduced a new frequency standard and test set, model number *1360*, which consists of a crystal-controlled oscillator, modulator, and a cathode-ray oscilloscope for observation of Lissajous figures. Special circuits consisting of modulators and filters are used to compare the fixed standard frequencies with a source frequency driving the subcarrier discriminator under test. Model *1360* can be supplied with any number of frequencies. The main advantage of this frequency standard is due to the ease of the adjustment procedure and the fact that any low-frequency oscillator can be used as an audio-frequency source for alignment of the telemetering equipment. It can be supplied with test and comparison oscillators. Additional information will be supplied by the Freed Transformer Company, Inc., at 1718–36 Weirfield Street, Brooklyn (Ridgewood) 27, N. Y.

Heavy-Duty Fuse Cutout. A new 100-ampere heavy-duty enclosed indicating fuse cutout has been announced by the Transformer and Allied Product Divisions of the General Electric Company, Schenectady 5, N. Y. For use on high-capacity distribution feeders or wherever high interrupting capacity is wanted, the new cutout has an interrupting rating of 5,000 rms amperes at 5,200 volts, and 8,000 rms amperes at 2,500 volts. The housing of the cutout is constructed of wet-process porcelain, glazed inside and out, and has a hanger support cemented into the back. Contact clips and terminals, silver-plated for high conductivity, are cemented into the housing interior. A barrier of synthetic sponge rubber forms a seal between the upper and lower contacts and prevents arc gases from causing flashovers. When the fusible section of the fuselink melts, a spring-operated indicator arm pulls the cable downward and completely out of the tube, assuring quick interruption even with 1-ampere links. The protruding indicator arm then clearly shows that the fuse has blown. Additional information may be obtained from the General Electric Company.

Universal Roentgen Meter. A radioactivity measuring instrument, the Universal Roentgen Meter, is now being produced by Westinghouse. The meter is the measuring part of radiation detection devices which reveal radiation, expressed in milliroentgens, that the device detects, thus indicating the amount of radioactivity present in any area. A roentgen is the basic measuring unit of alpha, gamma, and beta rays, which may be produced by an X-ray machine, a piece of radium, or an atomic bomb explosion. The meter is equipped with multiple scales, either four, five, or six, which make possible fine readings in all ranges of radiation. The 4-scale model covers four ranges of radiation: zero to half a milliroentgen; zero to five milliroentgens; zero to 50 milliroentgens;

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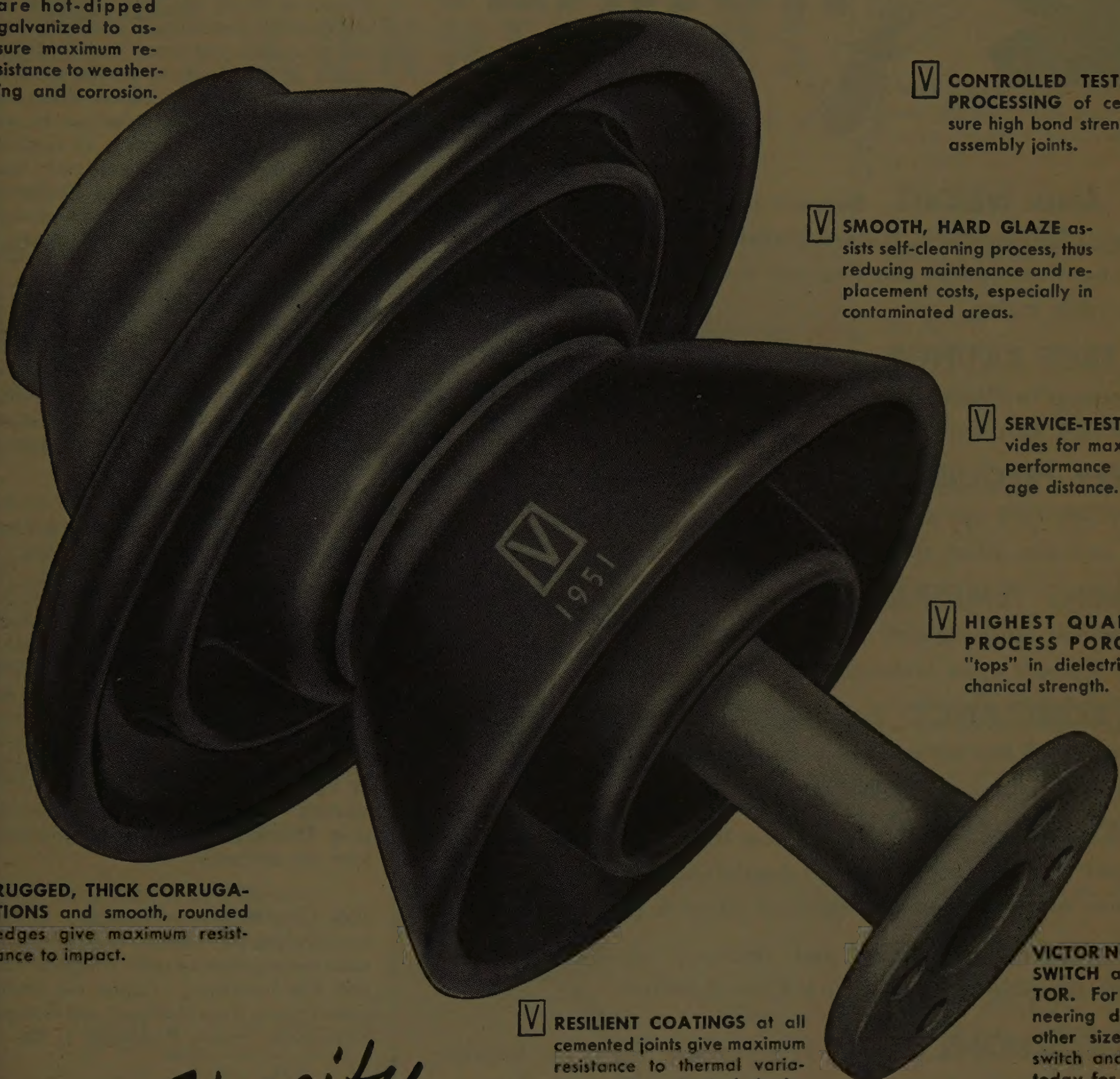

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and zero to 500 milliroentgens. For further information, write Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

TRADE LITERATURE

Instrument Transformers Manual. A well-illustrated 76-page manual, *GET-97A*, covering the theory of operation and the application of instrument transformers has been announced as available by General Electric's Meter and Instrument Divisions. Priced at $1.00, the new "Manual of Instrument Transformers" has been written for practicing engineers and students engaged in the fields of power generation, transmission, and application, where metering and relaying problems can be solved by the correct application of instrument transformers. The manual may be obtained from the Apparatus Department, General Electric Company, Schenectady 5, N. Y., for the price mentioned above.

Communications Reference Book. The 1951 edition of the Radio Corporation of America's reference book, containing basic data on RCA tubes, electronic components, test equipment, batteries, and miniature lamps, has been announced. It is available only through RCA tube and parts distributors.

Expulsion-Type Lightning Arresters. The Electric Service Manufacturing Company, 17th and Cambria Streets, Philadelphia 32, Pa., has issued a 40-page publication on lightning arresters. The first ten pages are devoted to the commercial and semitechnical data on the Keystone expulsion-type lightning arrester; the latter pages, the Engineering Section, are largely technical, and discuss the basic facts covering the design, construction, and operation of lightning arresters of this type. The booklet, "Keystone Expulsion Type Lightning Arresters," is available upon request from the company.

Pole Line Hardware Catalog. Hubbard and Company's "Catalog Number *50*" contains descriptions of their complete line of pole line hardware. Copies are available upon request from Hubbard and Company, 6301 Butler Street, Pittsburgh 1, Pa.

Electrode Guide. A new 56-page electrode guide, bulletin *R7-8*, covering all P & H welding electrodes, may be obtained upon request from the Harnischfeger Corporation, Welding Division, 4400 West National Avenue, Milwaukee 14, Wis.

Subminiature Tube Data. "Sylvania Subminiature Tubes" is a characteristic chart published by Sylvania Electric Products, Inc., which provides average characteristics of 30 commercially available subminiature electron tubes ranging from

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0.200-inch to 0.383-inch in diameter. The chart also provides suggestions for mounting, shielding, and application to obtain maximum life for tube types, including those rated up to 5,000 hours. The chart is available from Sylvania Electric Products, Inc., Emporium, Pa.

Preferred Utilities Catalog. A new 160-page catalog, bound in DuPont Fabricord, detailing standard quality equipment used for automatic heat and automatic power installations has been issued by the Preferred Utilities Manufacturing Corporation, 1860 Broadway, New York, N. Y. The price of the catalog is $2.50.

Starter Data. The Arrow-Hart and Hegeman Electric Company, 103 Hawthorn Street, Hartford 6, Conn., has announced the availability of a new engineering data folder on their new line of magnetic starters and contactors in sizes zero, 1, 2, 3, and 4. The folder contains ratings, dimensions, and engineering and design data.

Air Foam. A new brochure on air foam or mechanical foam for fire fighting has been released by the Pyrene Manufacturing Company, 560 Belmont Avenue, Newark 8, N. J. It is available upon request.

Precious Metal Alloys. Technical and application data on Ney precious metal alloys developed for use in industrial fields are contained in a new catalog and data book, bulletin *R-12*, available from the J. M. Ney Company, 71 Elm Street, Hartford, Conn.

Welding Engineering and Design. First in the Eutectic National Defense Service Series of free technical handbooks on the latest developments in welding materials and techniques, the "Manual of Welding Engineering and Design" is available upon request from the Technical Information Service, Eutectic Welding Alloys Corporation, 40 Worth Street, New York 13, N. Y.

How to Select Passenger Elevators. A 56-page booklet, the "Buyer's Guide for Passenger Elevators," available from the Westinghouse Electric Corporation, was compiled specifically to serve as a reference book on efficient vertical transportation in office buildings, hotels, department stores, apartment houses, and other public buildings, for the consulting engineer or architect. The seven sections of the book include detailed information on the different types of elevator controls and proper selection; selecting the correct number of elevators of the size and capacity; budget pricing data; dimensioned layouts for standard passenger elevators; installation information; safety features; and modernization of outmoded elevator systems. A copy of the booklet, *B-4572*, may be obtained by writing to Mr. E. B. Dawson, Elevator Division, Westinghouse Electric Corporation, Jersey City, N. J.

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